Chapter 11

Effect of social isolation on suicide

In the previous chapter we studied the effect of weakened marital bonds on suicide. Of course, the family unit is only one of the entities to which an individual belongs. In the language of physical interactions, family bonds are short-range ties whereas links with the society at large can be seen as long-range ties. Intermediate between short- and long- are medium-range ties with relatives, friends, neighbors, colleagues, etc. Typically, these links have a duration of a few years, whereas family ties have a duration of several decades.

A quick estimate of the strength of long-range ties can be obtained through the extreme value approach. It leads us to analyze the impact on suicides of major events such as the attacks on Pearl Harbor or September 11, 2001. We will see that even such dramatic events have no visible effect on suicide rates. In the subsequent sections, we consider various situations of social isolation such as illness, imprisonment or emigration. In each case the excess-suicides with respect to the general population can be taken as a proxy of the social ties which are missing or severed.

1 Effect of major historical events on suicide

First we examine the effect of the attack of September 11; then, we discuss more briefly the consequences of the attack of Pearl Harbor.
1.1 September 11, 2001

In accordance with the extreme value approach we consider the number of suicides in the place where one may expect the effect to be greatest, namely in New York City. The series in Table 11.1a gives the monthly numbers of suicides in the three years 2000-2002. At first sight, the figure for September 2001 does not appear abnormally lower or higher but the matter needs to be considered more carefully, in particular because of the seasonal pattern of suicide rates. The monthly means of 2000 and 2002, \( e_m = \left[ s_m(2000) + s_m(2002) \right] / 2 \), \( m = 1, \ldots, 12 \), were taken as reflecting the monthly pattern; thus, the relative differences \( p_m = \left[ s_m(2001) - e_m \right] / e_m \) furnish estimates of how much the monthly data of 2001 differ from the normal monthly pattern. This variable is displayed in Fig. 11.1a. The graph confirms our first conclusion namely that the fluctuation of September 2001 is smaller than the standard deviation of monthly fluctuations.

Incidentally, it can be observed that this episode provides an objection to the Werther effect that we discussed in chapter 3. In its initial presentation by Phillips (1974) the Werther effect is presumed to be an imitation effect through which people who read or hear about recent occurrences of suicides are tempted to commit suicide themselves. On September 11, people committing suicide by jumping from the Twin Towers were shown repeatedly on TV, yet without producing any identifiable imitation effect\(^1\).

As the attack of September 11 was an event of short duration, a kind of delta function shock, its effect on suicides may also be short-lived. In other words, one may wonder if there is a visible effect on daily numbers of suicides. With only about 40 suicides per month in New York City, there would be less than two suicides a day; clearly, a series with such small numbers would be meaningless. In other words, daily suicide data will be of significance only at the level of the whole country. Assuming an

\(^1\)It could of course be argued that there have been two opposite effects which canceled each other out: (i) an imitation effect which lead to additional suicides (ii) a "polarization effect" that resulted in a reduction of suicides. So far, however, there is no evidence in favor of such an interpretation.
annual suicide rate of 10 per 100,000 and a population of about 300 millions we expect a daily number of suicides of the order of $3000/365 = 82$. This is indeed the correct order of magnitude as shown by the data in Table 11.1b. The table gives the data for the first two weeks of September starting with the first Sunday of September. Thus, the figures in the first column are for Sundays, those in the second column are for Mondays, etc. September 11, a Tuesday, is the day delimited by asterisks. At first sight this figure is neither substantially lower or higher than other Tuesdays. In order to get rid of the daily pattern we use the same procedure as previously, that is we compute the daily means $e_d$ of 2000 and 2002; the relative differences $[(s_d(2001) − e_d)] / e_d$ then give an estimate of how much the daily data differ from the daily pattern. This variable is displayed in Fig. 11.1b. The graph confirms our first impression in the sense that the fluctuation of September 11 was of a size which occurs every two weeks as a result of random fluctuations.

1.2 Pearl Harbor

Was the suicide rate in December 1941 abnormal (either lower or higher) in some way? By applying the same procedure as previously we find that the change in $p = (s−e)/e$ is 1% which is well below the standard deviation of the series which is approximately equal to 5%. Taking a broader view, we can observe that the suicide rates in the U.S. decreased from 1933 to 1944 and that the beginning of the war in December 1941 had little effect on this trend. For instance, the maximum of 1942 (which occurred in April) is at the same level as the maximum of 1941 (also in April).

1.3 Weakness of long-range ties

In conclusion, major events which occur at the level of the nation state seem to have no effect whatsoever on suicide rates. In other word, the long-range links between individuals and the nation state appear to be much weaker than short-range links. This applies to events of short duration such as September 11 as well as to events
of longer duration such as Pearl Harbor and the subsequent battles which took place in the Pacific in the spring of 1942. It may be observed that these events affected directly the life of only a small proportion of the people. In both cases the number of victims was about 3,000 which represents a small percentage with respect to the population of the United States but also with respect to the population of New York City (0.4%). Naturally, the situation changed completely after 1942 when the lives of millions of Americans were directly affected by the war in particular for those who served in the armed forces. At this point one would certainly expect a substantial impact on suicide rates because such changes alter family ties. However, in such a period of time, many social changes took place simultaneously which means that it is not a favorable situation for sorting out the effects of different factors.

The picture which emerges from this discussion comprises a spectrum of bonds and links with strong short-range marital ties and one end and weak long-range interactions at the other end. In between are medium-range interactions for which we have no clear evidence so far. It is the purpose of the next sections to shed some light on this question.

2 Effect of social isolation on suicide

In what follows we consider several situations which are characterized by the severing of one or several sorts of ties. Table 11.2 provides an overall view of the corresponding suicide rates.

Why did we include people with schizophrenia in a table about social isolation? Schizophrenia is a severe mental illness characterized by a variety of symptoms among which the loss of contact with reality and social withdrawal play a great role. People with schizophrenia avoid others or act as though others do not exist; for instance, they may lack interest in participating in group activities. Clearly, the interpersonal links of people with schizophrenia are severely curtailed. Suicide rates
of people with schizophrenia are not well known. One reason may be the fact that the characterization of schizophrenia involves a degree of uncertainty. Estimates range from 10 to 20 times the rate in the general population.

The Asperger syndrome is a form of autism but what characterizes people with this syndrome compared to others with autism is that they have good language skills and average or above average intellectual quotient. Instead of being withdrawn, a person with Asperger syndrome may talk on and on, regardless of the listener’s interest. The average suicide rate of people with Asperger syndrome is not known precisely but a study by the National Autistic Society in Britain found a 8% rate of suicide and attempted suicide. If confirmed this would be a very high rate for it is usually estimated that in the general population there are 10 suicide attempts (with hospitalization) for every suicide. This would put the rate of suicide and attempted suicide at about 0.15% which is 50 times smaller than the above figure of 8%. People with Asperger syndrome also seem to have a higher divorce rate than the general population.

The other cases in Table 11.2 concern suicide among inmates and immigrants. In contrast to the previous categories, these are well defined situations for which detailed data are available.

### 2.1 Suicide among inmates

Persons who are arrested and jailed are removed from their normal social environment and, as a result, their short- and medium range links are suddenly severed. However, after several months in jail, inmates are likely to build up new ties for instance with other inmates or with guardians, chaplains, lawyers. One would expect therefore that it is during the first days in jail that the disaggregation of social ties is the most severely felt. This prediction is indeed confirmed by observation. It turns out that suicide rates are particularly high during the first days spent in jail (Fig. 11.2). A study about jail suicide in the U.S. performed in 1986 found that during the first hours after incarceration the suicide rate reaches very high levels or the order
This study found that 51% of the suicides which occur in lock up jail happen in the first 24 hours after the arrest. Lock up jails are detention facilities where detainees usually stay for less than 72 hours before being transferred to county jails; in U.S. terminology jails designate facilities for periods of imprisonment of less than one year whereas prisons keep detainees for periods exceeding one year.

How accurate and reliable are these data? An official report (Hayes and Rowan 1988) found under-reporting of suicides to be of the order of 40% nationally but with great differences between states. Thus, in New York State no under-reporting was identified whereas in Alabama, Louisiana, Pennsylvania, or Tennessee under-reporting was as high as 50%. As there is no mention of over-reporting we can be assured that the statistical data provide at least reliable lower bounds.

Table 11.2 gives also some data for other countries. These statistics do not distinguish between short- and long-term facilities. Most of the figures are comprised between 100 and 200 which is consistent with the rates observed in U.S. county jails.

It could be argued the the high suicide rate shortly after incarceration should be attributed to the trauma of the arrest rather than to the severance of social links. Possible ways of choosing between the trauma and the link interpretation would be to find situations in which there is a sharp increase in suicides without initial trauma or, conversely, which involve an initial trauma but do not result in higher suicide rates. In what follows both tests will be used.

### 2.2 Suicide in solitary confinement

The evidence on which we rely in this paragraph concerns suicides of inmates in solitary confinement cells in New York State prisons. Also called “special housing units” these cells are used for the purpose of punishing inmates for rebellious behavior. The regime of these cells implies confinement 23 hours a day. On December 31, 2001 there were 3,654 inmates in solitary confinement representing 5.4% of the total
population of the 67,000 inmates in New York State.

Over the four years 1998-2001 there were on average 5 suicides per year in solitary confinement cells which results in an annual rate of \( \frac{5}{(3654/10^5)} = 137 \) per \( 10^5 \); this figure should be compared with the rate of 26 per \( 10^5 \) in prison (Poughkeepsie Journal, articles by Mary B. Pfeiffer, Dec. 16, 2001 and Apr. 14, 2002). As the numbers of suicides in confinement are small, one may wonder to what extent the difference \( d = 137 - 26 \) is really significant. Through a reasoning of which we omit the technical details one arrives at the conclusion that \( \frac{d}{\sigma(d)} = 1.9 \). In other words (see Table 3.2) the likelihood that the difference \( d \) is due to a random fluctuation is one chance in 40.

Having assessed the significance of this difference in suicide rates, let us now examine how it can be explained in the network perspective on the one hand and in the trauma interpretation on the other hand. In the first perspective the higher suicide rate would be attributed to the severance of the ties with inmates before the shift to confinement and to the difficulty of building new ties once in confinement. In the trauma interpretation one would argue that the shift from prison to confinement creates a shock which accounts for the higher suicide rate. At this point it is still difficult to decide which interpretation is correct, but some light will be thrown on the question by considering the so-called “silent system” that was used in the penitentiary system in the nineteenth century.

2.3 The silent system

Starting from the premise that prisoners learn criminal ways from each other and that isolation, on the contrary, would put them face to face with their conscience, prison reformers introduced the silent system (Villermé, 1820). Architecturally, these penitentiaries were designed to minimize contact between inmates and between inmates and staff. During most of the day prisoners were kept isolated in individual cells; exercise was permitted only in small solitary yards whose high walls prevented contact
with fellow inmates (Telzrow 2002). In 1848, the English writer Charles Dickens was authorized to visit the Pennsylvania penitentiary. In his account he wrote: “A prisoner is a man buried alive” (Dickens 1842). In such conditions the network perspective would lead us to expect high suicide rates\(^2\). This was indeed the case although the evidence available is fairly scant.

- In one of his lectures, the prominent British lawyer Louis Blom-Cooper (1987) declared that after the adoption of the silent system in Britain the suicide rate among prisoners was as high as 1,760 per 100,000.
- High rates are reported in Table 11.2 for Belgium and Saxony, two countries which were among the first to adopt the silent system.

These high rates are difficult to explain in the trauma interpretation for in the silent system confinement is not a punishment but rather the permanent condition of prisoners.

In the next section we will see that the data available about suicide in prison may give us some insight into the time it takes for a network of social ties to form.

### 3 Effect of a rearrangement of social ties

A first set of evidence is offered by British remand centers. These are jails where prisoners are held while waiting for their trials. Usually, stays in remand centers are shorter than 6 months. As a result, their population is in majority composed of “new” prisoners. The following table shows that the transient state which characterizes these prisoners results in suicide rates which are about three times as high as the average prison rate.

\(^2\)Naturally, the actual occurrence of suicides is conditioned by the availability of means for committing suicide. If there are no sheets, towels, glasses, windows, nor any thing that could be used as a knife, committing suicide becomes nearly impossible. However, living in such conditions may affect the prisoner’s mental health to the point that he is likely to commit suicide as soon as he is allowed to leave the confinement cell.
<table>
<thead>
<tr>
<th>Type of prison</th>
<th>Annualized suicide rate (per 100,000 of average daily population), 1996-1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remand centers (stays shorter than 6 months)</td>
<td>389</td>
</tr>
<tr>
<td>Total prison population</td>
<td>119</td>
</tr>
</tbody>
</table>


This observation is interesting in two respects. (i) The fact that the suicide rate in remand centers is higher than in solitary confinement is at first surprising. Probably the simplest explanation is that prisoners have more means at their disposal for committing suicide in remand centers than in solitary confinement cells. (ii) The analogues in the U.S. of the British remand centers are the jails. But whereas in remand centers stays are limited to 6 months, in jails they are limited to one year. This is probably the reason why suicide rates in remand centers are twice as high as in jail.

**Moving from one prison to another** In a study done by MacDonald and Sexton (2002) we learn that suicide rates are increased *every time* a prisoner is moved from one prison to another. If time is counted from the day a prisoner arrives in a prison, the data show that there are approximately as many suicides during the first 6 days as during the following 53 days. In other words the annualized suicide rate is about 9 times higher in the first 6 days than in the two following months. This observation should be considered as fairly robust because it relies on a set of data which covers the 11 years 1990-2000.

**Release from prison** Normally one would not interpret the fact of being released as a trauma. In the tie perspective the surge of suicides in the first week has a natural interpretation as being caused by a transient readjustment of social ties. However, Table 11.3 also reveals that there is a surge in accidental and naturals deaths. The following explanations may be useful for the interpretation of these data.

- Prisoners with a fatal illness are often released in their last weeks of life.
- While the supply of alcohol and drugs is limited in prison, all of sudden intoxicants become available. In a sense, however, their excess-consumption can be seen as a kind of suicidal behavior.
• Life in prison provides a protection against many forms of accidental death, such as for instance being run over by a car or drowning. Furthermore, it is more difficult to commit suicide in prison than outside.

• The ex-prisoners considered in the study on which Tables 11.4 are based were under community supervision. However, the periods of supervision were limited in time and when coming to its end, the person under consideration dropped from the statistical sample. Any death occurring afterward would not be recorded. Such a statistical procedure naturally records a higher proportion of deaths occurring shortly after release than would be the case if all deaths were recorded no matter how long after release they happen.

These explanations account for the high rate of mortality by illness or accidents in the days following the release. However, they do no invalidate our observations regarding the surge in suicides as reflecting a rearrangement of social ties.

Is there a similar effect in physics for interactions between molecules? When two liquids $A$ and $B$ are mixed there is a transient state during which new $A - B$ bonds are established. What is the duration of this transient state? One should distinguish two characteristic times, one at molecular level and the other at macroscopic level. At the molecular level the characteristic time of bond rearrangement is very short, typically of the order of $10^{-9}$ seconds. For instance, when two molecules interact through the attraction due to induced densities of charge (the so-called London interaction) this interaction changes every $10^{-10}$ second; similarly it can be recalled that in a gas at room pressure and temperature the mean time between collisions is of the order of $10^{-10}$ (Reif 1965, p. 471). However, before a new $A - B$ bond can be established the molecules must be close enough. Apart from diffusion, there is no natural mechanism which ensures the mixing of two liquids, and diffusion can take a very long time (of the order of several days) especially if the densities of the liquids are fairly different. This *macroscopic time* only plays a role when one considers the
mixing of two macroscopic volumes of liquid; if a few $A$ molecules are introduced into the $B$ liquid, they are immediately in close contact with $B$ molecules. This is what happens in the remand centers considered above in so far as the prisoners arrive one by one. However, the macroscopic mixing time plays a great role when immigrants form communities which have little contacts with the population of the country where they are established.

The previous observations showing a sharp decrease in suicide rates over a time scale of a few weeks suggest that the characteristic time for the establishment of social ties in prison or in remand centers is of the order of several weeks. The sudden surges in suicide rates after an arrest or after a shift from one prison to another suggest that after the ties have been cut, the peak in suicides which follows occurs within a few days or, at most, a few weeks. If this order of magnitude is correct one would expect the same characteristic time for the suicide of young widowers. In other words, the mean time between the death of the wife and the suicide of the widower should be of the order or a few weeks, a prediction which it should be possible to test when adequate data become available.

We now turn to studying the effect on suicides of the social disruption experienced by immigrants.

4 Effect on suicide of the social disruption experienced by immigrants

In the previous section we studied the effect of social isolation when a person is taken into custody. Naturally, this is only one of several possible mechanisms leading to a disruption of social ties; the process of emigration that we consider in this section is another. Back in the nineteenth century when an individual or a family emigrated from an European country (say Italy for instance) to the United States it implied a sharp interruption in the contacts with the relatives and friends left behind. Furthermore, until the language barrier was surmounted it was not easy to establish social
ties with American people, except of course with other Italian immigrants. This was certainly an important factor in the creation of communities mainly composed of immigrants such as the “Little Italy” district in South Manhattan.

From a network perspective one would expect the suicide rate of immigrants to be inflated by the weakening of their social ties. Fig. 11.3 a and b show that the data points are above the line $y = x$ which means that the suicide rates of immigrants are higher than in their respective countries of origin. In addition, the graphs show that there is strong correlation between the rates in the U.S. and the rates in the countries of origin; the correlation is equal to 0.70 for Fig. 11.3a and 0.85 for Fig. 11.3b. The regression coefficients are given by:

$$1870 - 1880: \quad s(NY) = as(origin) + b \quad a = 1.5 \pm 1.0 \quad b = 18 \pm 8 \quad (11.1)$$

$$1910: \quad s(US) = as(origin) + b \quad a = 1.3 \pm 0.6 \quad b = 6.9 \pm 4 \quad (11.2)$$

where $s(origin), s(NY), s(US)$ denotes the suicide rates in the country of origin, in New York City and in the U.S. respectively.

This observation has an important implication. The suicide rates of groups of immigrants appears to be a cultural attribute of these groups of immigrants just like their language, traditions or diet. We do not yet have a comprehensive explanation of this effect but in a sense it is consistent with the fact that immigrants tend to reproduce their former social networks in the new country where they have settled. Naturally, it would be of great interest to be able to follow the changes in their suicide rate in the course of time as they become better integrated. We will come back to that question at the end of the chapter.

According to our previous argument the suicide rate of immigrants at the time or their arrival are disconnected from American suicide rates. They can be lower or higher. An example of the first kind is provided by Italians immigrants: in their country of origin their suicide rate is 6.3 per $10^5$, through immigration it jumps to 11.2 which however is still lower than the rate of Americans (15.3); another example of this kind
is provided by Hispanic immigrants which we consider more closely in a moment. Examples of the second kind are provided by most other European countries listed in Fig. 11.3.

Incidentally, it can be noted that the high correlation between suicide rates in the countries of origin and in the U.S. proves that suicide statistics are indeed trustworthy in the sense that the statistical estimates measured in the countries of origin are corroborated by independent estimates made in America. This observation invalidates most of the reservations expressed by some authors such as for instance Douglas (1967)\(^3\).

During the nineteenth century and during the first half of the twentieth century most immigrants came from European countries where (with the exception of Ireland and Italy) suicide rates were fairly high. Thus, immigration was a factor which tended to raise suicide rates in the United States. On the contrary, in the late twentieth century immigrants mainly came from countries such as Mexico and Central America where suicide rates are much lower than in the U.S.; this immigration therefore tended to lower suicide rates in the U.S. In the next section we investigate this effect more closely.

5 Effect of immigration on suicide rates in the country of destination

As immigration is only one of the factors which affect suicide rates, it may not be easy to identify the impact of this factor; therefore, in accordance with the extreme value methodology we consider historical episodes characterized by a huge influx of immigrants.

\(^3\)For a useful discussion of the arguments presented by Douglas see Besnard (1976) and Baudelot, Establet (1984).
5.1 Immigrants with high suicide rates

In the case of the United States, the most favorable episode is the period 1845-1865. Indeed, it is in this period that immigration reached its highest rates, culminating at 18 per 1,000 in 1854 (other local maxima were 15 in 1882 and 12 in 1914). Moreover, during 1845-1865, most of the immigrants came from Germany where suicide rates were particularly high. Thus, we are in the best conditions to observe the impact of immigrants on U.S. suicide rates.

For the nineteenth century, suicide statistics are available only in a few registration cities. Fortunately, New York City the arrival port of most immigrants, is one of them. Fig. 11.4 shows that suicide rates in New York are well correlated with immigration rates. Note that the curve of the suicides has been shifted back 3 years which means that on average the suicide of new immigrants occurs 3 years after their arrival.\(^4\)

Is the magnitude of the change in suicide rate compatible with the magnitude of the influx of immigrants? We do not know how many immigrants stayed in New York City after their arrival. For the sake of simplicity let us make the (provisional) assumption that all immigrants remained in New York City. During the 6 years 1849-1854 the average annual immigration rate in the U.S. was 13 per 1,000 which over the 6 years represents a cumulated number of \(13 \times 6 = 7.8\%\). As the population of New York City was about 8 times smaller than the U.S. population the rate of immigration was 8 times greater that is \(7.8 \times 8 = 62\%\). With these simplifying assumptions a sample of 100,000 New York residents in 1849 would comprise 162,000 people in 1854 of which 62,000 would be immigrants that is to say a proportion of \(62/162 = 37\%\).\(^5\) For the sake of simplicity we also assume that all immigrants have the suicide rate of the Germans (which composed the largest group) that is to say about 35 per

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\(^4\)Three years is a time lag which is much longer than the few weeks observed in shifts from one prison to another which suggests that the three years correspond to a macroscopic mixing time. Immigrants did not come alone and for a while their fellow countrymen provided substitutes for the links that were severed through their departure.

\(^5\)In 1875, the population of New York City comprised 44% foreigners
Starting from a suicide rate of $s_{1849} = 6$ we get in 1854 a suicide rate of $s_{1854} = 0.43 \times 6 + 0.37 \times 35 = 15.5$. If we assume that only one half of the immigrants remained in New York City during the 6 years, we get instead: $s_{1854} = 0.82 \times 6 + 0.18 \times 35 = 11.2$. which is close to the rate actually observed in 1854. In short the orders of magnitude seem to be plausible. Furthermore, if we assume that the rate at which immigrants leave New York City is fairly constant the parallelism between the two curves after 1855 gets a natural interpretation.

One may wonder what effect immigration has on suicide rates in the country of origin. A simple argument shows that it is likely to push suicide rates up. In a general way, suicide rates are known to increase with age and this is especially true for males. As emigrants are mainly young people under 40 the country which they leave will experience an increase in the proportion of its population which is over 40. This will result in a higher crude (as opposed to age-standardized) suicide rate.

We now turn to Hispanic immigration where immigrants have a suicide rate which is lower than the average suicide rate in the United States.

### 5.2 Effect of Hispanic immigration on U.S. suicide rates

Between 1990 and 2002, the U.S. suicide rate fell from 12.4 to 11.0 per 100,000. Some researchers attributed this decline to the growing use of anti-depressants and particularly of Prozac\(^6\). In recent years there has been a growing tendency to explain suicide by psychological factors. In the present section we propose a testable explanation of the fall of suicide rates as being due to Hispanic immigration. First, we give some crucial parameters about Hispanic immigrants and in a second step we present a statistical test based on suicide rates in Californian counties.

The suicide rate of Hispanics in the United States was 5.6 in 2001 and 5.0 in 2002\(^7\).

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\(^6\)See the following articles: “Suicide rate down in the era of Prozac” (The Nation, 5 February 2005); “Antidepressants save lives” (http://washingtontimes.com).

\(^7\)Morbidity and Mortality Weekly Report (MMWR), Centers for Disease Control, June 11, 2004, p. 478-481; National
For the purpose of comparison the suicide rate in Mexico was about 3.0 per 100,000 (Puentes-Rosas et al. 2004). It is of interest to observe that the ratio $5.3/3.0 = 1.8$ is consistent with the data about immigrants from other countries given in Fig. 11.3a,b.

As the rate of 5.3 is only one half of the U.S. rate, an influx of Hispanics lowers the U.S. rate as surely as the addition of cold water to hot water lowers the temperature of the mixture. Furthermore the fall in suicide rates should be greater in areas where there has been a large influx of Hispanics. Fig. 11.5a provides a test based on Californian counties. For each of the 58 counties the plot shows (i) the percentage of Hispanics in its population in 1996 (ii) the average suicide rate over the 5-year interval 1994-1998. The coefficient of correlation is -0.76 which confirms the connection between the level of suicide rates and the presence of Hispanics.

A more detailed examination shows that in fact the relationship is not linear. The dotted curve represents an average performed over successive groups of five points. How can that non-linearity be interpreted? Let us denote by $t_1$ and $t_2$ the suicide rates of non-Hispanics and of Hispanics respectively. If these rates were independent of the proportion of Hispanics ($x$) the total suicide rate ($t$) would be given by:

$$t = (1 - x)t_1 + xt_2 = (t_2 - t_1)x + t_1$$

Thus, the fact that the relationship is not a straight line shows that $t_1$ and $t_2$ are in fact functions of $x$. For the sake of simplicity let us assume that these functions are linear:

$$t_1 = \alpha_1 x + \beta_1 \quad t_2 = \alpha_2 x + \beta_2$$

As a result, the function $t = t(x)$ becomes the equation of a parabola:

$$t = x^2(\alpha_2 - \alpha_1) + x(\beta_2 - \beta_1 + \alpha_1) + \beta_1, \quad 0 \leq x \leq 1$$

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Although not all Hispanic immigrants came from Mexico, immigrants from Mexico represented the largest national group; moreover the suicide rates in other Latin American countries were of the same magnitude as in Mexico.
Because of the concavity of the curve in Fig. 11.4a one obtains the condition: $\alpha_2 > \alpha_1$, a prediction which it will be possible to test when suicide rates become available separately for non-Hispanics and Hispanics.

As a second test of the relationship between the fall in suicide rates in California and the influence of Hispanics we propose a longitudinal analysis for the two counties of Los Angeles and San Diego. Fig. 11.5b shows the total suicide rate as a function of the proportion of Hispanics for the four years 1980, 1990, 1996, 2000. The points for 1980, 1990 and 1996 fall fairly well on the regression line whereas the points for 2000 are markedly below the regression line. This may be due to the fact that the data for 2000 underestimates the number of Hispanics. It is usually assumed that in addition to the 30 million legal Hispanic immigrants there are about 11 million illegal immigrants (New York Times 2 May 2006). Adding 30% to the number of Hispanics changes of course the percentage of Hispanics (i.e. the $x$-variable) but it has also an effect on the suicide rate (i.e. the $y$-variable) The main point is that the number of suicides is not likely to be changed because death certificates are established for any death whether of a legal or illegal immigrant. However the denominator of the suicide rate refers to the total population which is of course the registered population. Therefore the correction will result in reduced suicide rates. The expected corrections are indicated by arrows in Fig. 11.5b.

6 Nonlinear mixing relationships

In this section we are interested in the suicide rate of a population which is composed of two separate subgroups. From a network perspective, this question can be stated in the following general form. If two separate networks $A$ and $B$ are characterized by intensive parameters $p_A$ and $p_B$, what happens when these networks are allowed to interact; in particular what is the new parameter $p_{A\cup B}$ of the global system defined in terms of $p_A, p_B$. A related question is how long it takes for the mixing of $A$ and $B$ to result in an equilibrium situation for the new network $A \cup B$. The first question is
an equilibrium problem while the second is a time-dependent issue.

To get some insight into this problem we need a dataset which fulfills the following conditions (i) The two subgroups $A$ and $B$ must have suicide rates which are sufficiently different. (ii) The distinction between $A$ and $B$ should not be based on religion for one knows that, at least after the nineteenth century, the religion of a group is little affected by the process of integration. There are very few countries which publish suicide rates for different components of their populations. It is thanks to the detailed statistical data published by the United States for the Black and White components of the American population that we will be able to study the suicide rates in these two subgroups. We begin our discussion with a cross-sectional analysis summarized in Fig. 11.6 a and b.

Fig. 11.6 a shows the suicide rates of Afro-Americans in 25 states as a function of the percentage of the Afro-American population. These states were selected on the basis of the two following criterions.

- In order to mitigate the influence of population densities we selected states whose densities are comprised between 20 and 200 people per square kilometer.
- In order to minimize statistical fluctuations we eliminated the states having less than 20 suicides over the period 1979-1998 (which means less than one suicide per year).

How should we interpret the positive slope of the regression line in Fig. 11.6a. First we can note that any slope, whether positive or negative demonstrates the existence of a collective effect of the social environment on the Black population. A fairly natural explanation would be to argue that Black people who live in a state with a high proportion of White non-Hispanics may adopt the ways and behavior of the people around them including their higher suicide rate. This explanation will be referred to as an immersion-contagion effect; it is a fairly anthropomorphic explanation in so far as the notions of behavior, of contagion or imitation have no clear translation in
network concepts. On the basis of this argument one would expect the suicide rate of White non Hispanics to decrease at the proportion of the Black population becomes greater. Yet, Fig. 11.6b shows that it is the opposite which is observed. In short, the immersion-contagion effect does not work. To nevertheless “save” this explanation one could argue that Whites are less likely to adopt the ways and behavior of their Black neighbors. Yet, even if one accepts this argument one still has to explain why the slope of the regression line is positive instead of being simply close to zero.

As the anthropomorphic explanation failed, let us try the network approach that we have been using throughout this book. A first step is to convince ourselves that what we observe in Fig. 11.6 a, b is a fairly standard case in the physics of liquid mixtures. If one wishes to draw a parallel with the mixing of two liquids, the analog of the suicide rate of population $A$ would be the ratio $^9$ (Number of molecules of $A$ in the vapor above the liquid) / (Number of molecules of $A$ in the liquid) \(\sim\) (Partial pressure $p_A$ of $A$ in the vapor above the liquid) / (Concentration $x_A$ of $A$ in the liquid). In the case of liquids which obey Raoult’s law this curve would be an horizontal line. In a solution with a positive deviation from Raoult’s law the curve of $p_A/x_A$ would be an increasing function of $x_B$ and similarly $p_B/x_B$ would be an increasing function of $x_A$. In short, this case corresponds to what we observe in Fig. 11.6a,b. Thus, in order (tentatively) to get an interpretation of these graphs we must recall the meaning (in terms of interactions) of a positive deviation from Raoult’s law. A positive deviation implies the following relationship between strengths of attraction: \((1/2) \left[ \text{str. of attract. in pure } A + \text{str. of attract. in pure } B \right] > \text{str. of attract. between } A \text{ and } B \text{ molecules in the mixture.}

We complement the previous cross-sectional studies by a longitudinal analysis of the White and Black components.

**Longitudinal analysis**  
Fig. 11.7 shows how the ratio of White to Black suicide

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$^9$The population $A$ is represented by the $A$ molecules in the liquid, the people of $A$ who commit suicide are represented by the $A$ molecules in the vapor above the liquid.
rates changed in the course of time between 1920 and 2002. In this time interval there has been a slow increase in the percentage of the Black population: it was 9.40% in 1920, 10.8% in 1970 and 12.8% in 2002. These slight changes certainly cannot account for the ups and downs displayed by the curve. Actually, the main message of Fig. 11.7 is that the ratio does not converge toward 1. As already noted this persistent gap can hardly be explained by religious factors\textsuperscript{10}. The curve for Blacks and Whites in Durban (South Africa) shows greater convergence of suicide rates. Clearly, additional data for other countries would be welcome but, as already noted, only few countries record suicide rates separately for different components of the population.

\textsuperscript{10}In 2000 the number of Muslim Afro-Americans was estimated at 3 million that is to say about 10% of the Afro-American population.
### Table 11.1a Monthly number of suicides in New York City, 2000-2002

<table>
<thead>
<tr>
<th>Year</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>44</td>
<td>36</td>
<td>33</td>
<td>48</td>
<td>44</td>
<td>37</td>
<td>27</td>
<td>43</td>
<td>32</td>
<td>39</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>2001</td>
<td>32</td>
<td>24</td>
<td>32</td>
<td>46</td>
<td>48</td>
<td>42</td>
<td>51</td>
<td>44</td>
<td>33</td>
<td>33</td>
<td>34</td>
<td>43</td>
</tr>
<tr>
<td>2002</td>
<td>42</td>
<td>35</td>
<td>36</td>
<td>48</td>
<td>56</td>
<td>34</td>
<td>42</td>
<td>36</td>
<td>44</td>
<td>40</td>
<td>50</td>
<td>32</td>
</tr>
</tbody>
</table>

Source: New York City Department of Health. Many thanks to Mr. J.F. Kennedy for sending me these data.
Table 11.1b  Daily number of suicides in the U.S. during the first two weeks of September, 2000-2002

<table>
<thead>
<tr>
<th>Year</th>
<th>S</th>
<th>M</th>
<th>T</th>
<th>W</th>
<th>T</th>
<th>F</th>
<th>S</th>
<th>S</th>
<th>M</th>
<th>T</th>
<th>W</th>
<th>T</th>
<th>F</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>73</td>
<td>70</td>
<td>88</td>
<td>85</td>
<td>80</td>
<td>78</td>
<td>77</td>
<td>68</td>
<td>85</td>
<td>100</td>
<td>99</td>
<td>82</td>
<td>78</td>
<td>74</td>
</tr>
<tr>
<td>2001</td>
<td>73</td>
<td>80</td>
<td>88</td>
<td>107</td>
<td>77</td>
<td>75</td>
<td>87</td>
<td>77</td>
<td>89</td>
<td><em>73</em></td>
<td>86</td>
<td>89</td>
<td>82</td>
<td>72</td>
</tr>
<tr>
<td>2002</td>
<td>83</td>
<td>87</td>
<td>110</td>
<td>102</td>
<td>79</td>
<td>96</td>
<td>59</td>
<td>72</td>
<td>103</td>
<td>81</td>
<td>80</td>
<td>87</td>
<td>90</td>
<td>75</td>
</tr>
</tbody>
</table>

Notes: The table gives the number of suicides for the first two weeks of September starting from the first Sunday in the month. September 11, 2001 corresponds to *73*.
Source: National Health Center Website (Vital Statistics, Mortality, Table 304)
Table 11.2  Effect of social isolation on suicide

<table>
<thead>
<tr>
<th>Condition</th>
<th>Suicide rate (s) [per 100,000]</th>
<th>s/(rate in general population)</th>
</tr>
</thead>
<tbody>
<tr>
<td>People with schizophrenia</td>
<td>200</td>
<td>20</td>
</tr>
<tr>
<td>Inmates in solitary confinement (U.S.)</td>
<td>140</td>
<td>7</td>
</tr>
<tr>
<td>Inmates in prison (Britain)</td>
<td>110</td>
<td>5</td>
</tr>
<tr>
<td>German immigrants in the U.S. (1870)</td>
<td>40</td>
<td>2</td>
</tr>
</tbody>
</table>

Notes: The purpose of the table is to give overall orders of magnitude. In the first case we assume a suicide rate in the general population of 10 per 100,000 which is approximately the rate for the U.S. or British population. In the second and third cases the general population is the male population. In the last case “general population” refers to the German population in 1870 which had a suicide rate of about 20/100,000.

Sources: Schizophrenia: Schizophrenia Society of Ontario (http://www.schizophrenia.on.ca); for the other cases, see subsequent tables.
### Table 11.3 Suicide rates among inmates

<table>
<thead>
<tr>
<th>Type of institution</th>
<th>Time elapsed since incarceration ($T$)</th>
<th>Location</th>
<th>Time interval</th>
<th>Annual suicide rate [per 100,000]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Lockup</td>
<td>$T &lt; 72$ hours</td>
<td>New York State</td>
<td>1990 – 1999</td>
<td>900</td>
</tr>
<tr>
<td>2 Lockup</td>
<td>$T &lt; 72$ hours</td>
<td>South Dakota</td>
<td>1984</td>
<td>2975</td>
</tr>
<tr>
<td>3 Jail</td>
<td>$72$ hours $&lt; T &lt; 1$ year</td>
<td>Texas</td>
<td>1981</td>
<td>137</td>
</tr>
<tr>
<td>4 Jail</td>
<td>$72$ hours $&lt; T &lt; 1$ year</td>
<td>South Carolina</td>
<td>1984</td>
<td>166</td>
</tr>
<tr>
<td>5 Jail</td>
<td>$72$ hours $&lt; T &lt; 1$ year</td>
<td>US</td>
<td>1986</td>
<td>107</td>
</tr>
<tr>
<td>6 Jail</td>
<td>$72$ hours $&lt; T &lt; 1$ year</td>
<td>New York State</td>
<td>1986 – 1987</td>
<td>112</td>
</tr>
<tr>
<td>7 Prison</td>
<td>$1$ year $&lt; T$</td>
<td>US</td>
<td>1984 – 1993</td>
<td>21</td>
</tr>
<tr>
<td>8 Not specified</td>
<td>Not specified</td>
<td>Belgium</td>
<td>1872</td>
<td>190</td>
</tr>
<tr>
<td>9 Not specified</td>
<td>Not specified</td>
<td>England</td>
<td>1872</td>
<td>112</td>
</tr>
<tr>
<td>10 Not specified</td>
<td>Not specified</td>
<td>Saxony</td>
<td>1872</td>
<td>860</td>
</tr>
<tr>
<td>11 Not specified</td>
<td>Not specified</td>
<td>Canada</td>
<td>1984 – 1992</td>
<td>125</td>
</tr>
<tr>
<td>12 Not specified</td>
<td>Not specified</td>
<td>New Zealand</td>
<td>1988 – 2002</td>
<td>123</td>
</tr>
<tr>
<td>15 Not specified</td>
<td>Not specified</td>
<td>Australia</td>
<td>1997 – 1999</td>
<td>175</td>
</tr>
<tr>
<td>16 Not specified</td>
<td>Not specified</td>
<td>Canada</td>
<td>1997 – 2001</td>
<td>102</td>
</tr>
<tr>
<td>17 Not specified</td>
<td>Not specified</td>
<td>Scotland</td>
<td>1997 – 2001</td>
<td>227</td>
</tr>
</tbody>
</table>

**Average (8-17)** 218

Notes: As a useful yardstick one can use the suicide rate among males in the United States between 1979 and 1998 which was about 20 per 100,000. Suicide rates of inmates are highly dependent upon the time, $T$, they have spent in prison since their incarceration. A detailed study based on 339 suicides that occurred in the US in 1986 found that 51 percent of the suicides occurred in the first 24 hours of incarceration. This observation is consistent with the interpretation of suicide as resulting from a severing of social ties. In the statistics published in other countries than the United States, the time of incarceration is not specified. However, since inmates incarcerated for less than one year are in greater number than those incarcerated for longer durations, one would expect the former to predominate. Therefore it is not surprising that the order of magnitude of suicide rates is more or less the same everywhere (one exception is Saxony).

Sources: 1: DCJ Report (tables 7,9,11); 2: Hayes et al. (p. 4); 3,4,5: Hayes et al. (p. 52-53); 6: DCJ Report (table 1), Hayes et al. (table 2); 7: http://www.mces.org/Suicide_Prisons_Jails.html; 8-10: Legoyt; 11: Correctional Service; 12: Corrections Department, http://www.corrections.govt.nz; 13: Her Majesty Prison Service; 14: Baron-Laforet, Bourgoin; 15-17: same as 12.
Effect of social isolation on suicide

<table>
<thead>
<tr>
<th>Situation</th>
<th>Suicide: number of deaths per week</th>
<th>Natural causes: number of deaths per week</th>
<th>Accidents: number of deaths per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>4.00 [1.00]</td>
<td>4.00 [1.00]</td>
<td>13. [1.00]</td>
</tr>
<tr>
<td>Weeks 2,3,4</td>
<td>1.70 [0.42]</td>
<td>2.33 [0.57]</td>
<td>8.3 [0.64]</td>
</tr>
<tr>
<td>Weeks 5-12</td>
<td>0.87 [0.22]</td>
<td>1.63 [0.40]</td>
<td>6.2 [0.47]</td>
</tr>
<tr>
<td>Weeks 13-24</td>
<td>0.54 [0.13]</td>
<td>0.66 [0.16]</td>
<td>5.9 [0.45]</td>
</tr>
</tbody>
</table>

Notes: The number within brackets show the data in normalized form (first week=1). At first sight one may be tempted to interpret the decrease in the number of suicides per week as reflecting a transient state marked by a reorganization of social ties. However, the parallel observations for deaths by natural causes and by accidents clearly require different explanations. In the case of death by natural causes a key-factor is the fact that terminally ill prisoners are released so they can die at home or in hospital. Alcohol is also an important factor.
Source: Sattar (2001, p. 34)
Fig. 11.1a  Effect of the attack of September 11, 2001 on monthly suicides in New York City. The curve represents the relative percentage differences $p_m = \left[ s_m(2001) - e_m \right] / e_m$, $m = 1, \ldots, 12$ between the numbers of suicides in 2001 and the means, $e_m$, for the corresponding months in 2000 and 2002. The purpose of this transformation is to discard the influence of the seasonal pattern of suicides. The small negative fluctuation of $p_m$ in September 2001 is well within the bounds of the standard deviation $\sigma_p = 25\%$. Source: See Table 11.1a.
Fig. 11.1b  Effect of the attack of September 11, 2001 on daily suicides in the United States. Week 1 begins on the first Sunday of September. A transformation \( p_d = \frac{(s_d(2001) - e_d)}{e_d}, \ d = 1, \ldots, 21 \) was performed to get rid of the daily pattern of suicides; \( e_d \) is the mean number of suicides on day \( d \) for 2000 and 2002. The negative fluctuation on September 11, 2001 is 1.78 times the standard deviation. The likelihood of such a fluctuation to occur randomly is one chance in 13; indeed the graph shows that there are two fluctuations of that magnitude in the 21-day period. *Source: See Table 11.1a.*
Suicide rate of inmates as a function of the time elapsed since their arrest. In the two days following incarceration, the suicide rate decreases rapidly. Subsequently, the decrease continues at a much slower rate. After two years the suicide rate becomes almost identical to the rate in the general male population. The decrease roughly follows a power law (at least until the plateau phase) with an exponent equal to -1.1: suicide rate = 1/(time elapsed since incarceration)^1.1. Sources: Hayes et al. (1988, p. 36); Roehner (2005 a, p. 669-670).
Fig. 11.3 a Suicide rates of immigrants in New York City (1870-1880). Each country abbreviation corresponds to a group of immigrants born in this country and who committed suicide in New York City (“Boh” means Bohemia, “Sco” means Scotland, the other labels are fairly transparent). The suicide rates in New York City are correlated with (but higher than) the suicide rates in the countries of origin. The correlation is equal to 0.70 and the slope of the regression line is $1.5 \pm 1$. The line $y = x$ is shown for the purpose of comparing the rates in New York with previous rates. The high dispersion is due to the fact that some of the suicide numbers are fairly small, for instance there were only 5 suicides from Denmark, 8 from Sweden and 10 from Italy, as compared to 626 from Germany. Sources: Suicide rates in NYC: Nagle (1882), suicide rates in countries of origin: Durkheim (1897), Krose (1906).
Fig. 11.3b  Suicide rates of immigrants in the United States (1910). Each country abbreviation corresponds to a group of immigrants born in this country and who committed suicide in the United States (“Hun” means Hungary, “Sca” means Scandinavia, the other labels are fairly transparent. The suicide rates in the U.S. are correlated with (but higher than) the suicide rates in the countries of origin. The correlation is equal to 0.85 and the slope of the regression line is $1.3 \pm 0.6$. The smallest number of suicides is 47 (Scotland) which explains that the dispersion is smaller than in the previous graph. Sources: Suicides in the U.S.: Mortality Statistics (1910, pp. 586-595); foreign born population by country of birth: Historical Statistics of the U.S. (1975, p. 117); suicide rates in country of origin: World Health Organization (1996).
Fig. 11.4  Suicide rates in New York City versus immigration rates in the U.S. Solid line: suicide rate in New York City (the curve has been translated back 3 years); broken line: immigration rate in the U.S. (per 1,000 of U.S. population). The correlation is 0.67 and the regression reads: suicide = a(immigration) + b, a = 0.89 ± 0.13, b = 4.5 ± 0.6. Sources: Suicide rates in New York City: Nagle (1882); immigration rate: Historical Statistics of the U.S. (1974, p. 106).
Fig. 11.5a  Relationship between percentage of Hispanics and suicide rates at county level. Each number refers to one of the 58 counties of California listed in alphabetical order. The correlation is -0.76 and the linear regression reads: \( y = (-0.25)x + 19 \). The dotted curve gives an average over successive groups of 5 points.

Sources: Percentage of Hispanics: U.S.A. Counties 1998 (website of the U.S. Census Bureau. Suicide rates: WONDER database (website of the Center for Disease Control.)
Fig. 11.5b  Suicide rates in Los Angeles and San Diego in 1980, 1990, 1996, 2000. The squares and circles refer to Los Angeles and San Diego respectively; if one excepts the light symbols (which concern 2000) the correlation is -0.96. A possible reason which may explain why the data for 2000 are outliers may be an underestimation of the number of Hispanics. The arrows indicate likely corrections as explained in the text. 

Sources: Same as for Fig. 11.5a.
Suicide rates of White non-Hispanics in American states and in the counties of Mississippi. Horizontal scale: Percentage of Afro-Americans; vertical scale: average suicide rate of White-non-Hispanics over the 20 year period 1979-1998. Each square represents the data for a state whereas the dots correspond to the counties of Mississippi. The counties of Mississippi were included because this state which has the highest proportion of Afro-Americans. Only states with less than 2% Hispanics were included in the sample so that the suicide rate of Whites given by the data can be identified with the suicide rate of White non-Hispanics. The correlation is 0.44 (confidence interval at 95% probability level is (0.26,0.59); the slope of the regression line is: 0.073 ± 0.03. The fact that the regression is not an horizontal line suggests that in their behavior with respect to suicide individuals are sensitive to their social environment. Sources: Same as for Fig. 11.5a.
Fig. 11.6b  Suicide rates of African-Americans in several states. Horizontal scale: percentage of White-non-Hispanic people in 25 states; vertical scale: Average suicide rate of Afro-Americans over the 20 year period 1979-1998. The correlation is 0.52 (confidence interval at 95% probability level is (0.15,0.75); the slope of the regression line is: 0.062 ± 0.04. Sources: Same as for Fig. 11.5a.
Fig. 11.7 Ratio of the suicide rate of Whites to the suicide rates of Blacks. Under the assumption of a convergence of White and Black social behavior one would expect a convergence of their suicide rates as well as of other social characteristics such as infant mortality. Observation shows that this did not happen; in spite of the fact that religious factors do not play an important role (as would be the case for Irish or Italian immigrants), the two suicide rates do not display any convergence trend over the past decades; for infant mortality (which is not shown here) there was a slow convergence until 1950 after which the two rates began to diverge. In this graph, “Whites” includes Hispanics, but until 1990 the percentage of Hispanics was small which means that the suicide rate of Whites can be identified with the rate of White-non Hispanics. Sources: 1) U.S., 1921-1940: Linder and Grove (1947, p. 272-273), 2) U.S., 1940-1960: Grove and Hetzel (1968, p. 373), 3) U.S., 1960-1979: Statistical Abstract of the U.S. 1969, 1981 4) U.S., 1979-2002: Wonder database (website of the Center for Disease Control. 5) South Africa: Meer (1976, p. 236). 6) Infant mortality: B. Roehner (2004)