The Welfare Cost of Violence

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Motivation

- More than 10 years of US presence in Vietnam: 58,000 lives lost.

- 90's: yearly average of more than 27,000 lives lost to violence in the US (homicides, injuries purposely inflicted and other violence).

- Colombia: population 7 times smaller than US; average of more than 28,000 lives lost to violence in every year of the 90's.

- Material costs of crime estimated to add up to 2.1% of the GDP in US, and may be as large as 3.6% for Latin America (Bourguignon, 2000; and Londoño and Guerrero, 1999).

- Introspection suggests that the welfare loss entailed by the exposure to the risk of victimization should also be extremely large.

Objectives and Main Results

- Estimate non-monetary costs of violence observed in 73 countries.

- Use WHO age and cause specific number of deaths to simulate survival function that would be observed in absence of violence.

- "Value of life" approach allows estimation of willingness to pay for lower violence rates (higher survival probabilities), for individuals at different ages.

- With population and age distribution, it's possible to aggregate MWP in order to obtain the social value of violence reductions.

- Appeal of such number: gives the sum of resources that a society is willing to spend in order to eliminate violence or, more generally, to reduce violence to some predetermined level.

- Results

  - Colombia: violence reduces life expectancy at birth by 3 years; social cost = 100% of 1995 GDP.

  - Brazil: violence reduces life expectancy at birth by 0.8 year; social cost = 38% of 1995 GDP.

  - US: violence reduces life expectancy at birth by 0.3 year; social cost = 13% of 1995 GDP.

  - One-unit increase in years of life lost associated with increase of 44% of the GDP in social cost of violence.

- Results support the popular belief that non-monetary costs of violence and crime are generally as important as material costs.

Summary

1. Theory

- Homicide rates have effects on mortality at different ages. We want to be able to value given changes in survival probabilities.

- Define $S(t,a)$ as the probability of survival to age t of an individual currently at age a.

- Assume that some exogenous factor v affects the survival function: $S(t,a;v)$.

- Define: $S_v(t,a) = \partial S(t,a;v)/\partial v$.

- Goal: give monetary values to $S_v(t,a)$.

- The problem of an individual at age a is

$$\max U(a) = \int_a^\infty e^{-\rho(t-a)} S(t,a) u(c(t)) dt,$$

$$\text{s.t.: } \int_a^\infty e^{-r(t-a)} S(t,a) y(t) dt = \int_a^\infty e^{-r(t-a)} S(t,a) c(t) dt;$$

where BC assumes complete contingent claims market.

- foc's: $e^{-\rho(t-a)} u'(c(t)) = \lambda_a e^{-r(t-a)}.$

- MWP for changes in *S(t,a)* is defined as:

$$MWP_a = \frac{\partial V(a)}{\partial v} \frac{1}{\lambda_a} = \frac{\int\limits_a^\infty e^{-\rho(t-a)} u(c(t)) S_v(t,a) dt}{\lambda_a}$$

$$+ \int\limits_a^\infty e^{-r(t-a)} (y(t) - c(t)) S_v(t,a) dt.$$

- Rearrange terms and use foc's:

$$MWP_a = \int\limits_a^\infty e^{-r(t-a)} \left[\frac{u(c(t))}{u'(c(t))} + y(t) - c(t) \right] S_v(t,a) dt.$$

- Defining $\varepsilon(c(t))$ as elasticity of $u(.)$:

$$MWP_a = \int_a^\infty e^{-r(t-a)}\left[\frac{c(t)}{\varepsilon(c(t))} + y(t) - c(t)\right]S_v(t,a)dt.$$

- Abstract from life cycle considerations: $r = \rho$ and $y(t)$ constant $(y(t) = y)$ ➜ $c(t) = c = y$.

$$MWP_a = \frac{y}{\varepsilon(y)}\int_a^\infty e^{-r(t-a)}S_v(t,a)dt.$$

- MWP_a: how much an individual at age a, earning y in every period of life, is willing to pay for changes in mortality $S_v(t,a)$.

- To illustrate, with deterministic lifetime (τ):

$$MWP_a = \frac{y}{\varepsilon(y)} e^{-r(\tau-a)} d\tau = \frac{u(y)}{u'(y)} e^{-r(\tau-a)} d\tau.$$

- This stresses two main determinants of value of reductions in mortality: value of income (or consumption) throughout life, and size and moment of the reductions in mortality.

  → Richer countries attach more value to given longevity gains.

  → Moment of mortality reductions is important because of competing risks (effect on τ) and discounting of the future.

- Social cost is the sum of the MWP_a of the entire population:

$$Social\ MWP = P \int_0^\infty MWP_a f(a)da.$$

2. Parameterization and Calibration

- Two relevant dimensions of $u(.)$: substitutability of consumption through time, and value of being alive relative to being dead:

$$u(c) = \frac{c^{1-1/\gamma}}{1-1/\gamma} + \alpha.$$

α arises from normalization of utility in death state to zero, and γ is intertemporal elasticity of substitution.

$$u(c) = \frac{c^{1-1/\gamma}}{1-1/\gamma} + \alpha.$$

- α determines level of annual consumption at which individual is indifferent between being alive or dead.

- α can be identified from inter-temporal elasticity of substitution and elasticity of the instantaneous utility:

$$\varepsilon(c) = \frac{u'(c)c}{u(c)} = \frac{c^{1-1/\gamma}}{\frac{c^{1-1/\gamma}}{1-1/\gamma} + \alpha} \Rightarrow \alpha = \frac{c^{1-1/\gamma}}{\varepsilon(c)} - \frac{c^{1-1/\gamma}}{1-1/\gamma}$$

- Murphy and Topel (2003) estimate $\varepsilon(c)$ using 1990 US data to be 0.346.

- Browning, Hansen, and Heckman (1999) suggest that γ is probably slightly above 1.

- With $\gamma = 1.25$, $\varepsilon = 0.346$, and US income in 1990: $\alpha = -16.16$ (we set $r = 3\%$.)

- With this functional form, MWP_a can be written as:

$$MWP_a = \left(\frac{y}{1-1/\gamma} + \alpha y^{1/\gamma} \right) \int_0^\infty e^{-r(t-a)} S_v(t,a)dt$$

- With parameter values discussed, income data, and changes in survival, we can calculate value of mortality changes.

- Though US data calibrates parameters, specification allows income-elasticity of MWP_a to vary with income level: 1.2 for $10,000; 1.9 for $1,000; and 3.8 for $500.

- Functional form is flexible enough to identify underlying preference parameters that, in principle, can be used more generally, irrespective of income level. No systematic bias, as long as cultural factors determining α are not correlated with y.

3. Data and Counterfactual Survival Functions

- Data:

➔ Age specific population and number of deaths from the World Health Organization Mortality Database.

➔ Deaths caused by violence defined as: deaths caused by "homicide and injury purposely inflicted by other persons, and other violence." From the World Health Organization Mortality Database (aggregate causes of death B55 and B56 in ICD-9).

➔ Income is real GDP per capita adjusted for terms of trade, in 1996 international prices (RDPTT variable from the PWT 6.1).

- Variables for 1995 calculated as averages between 1990 and 1999. Sample includes all countries for which data are available (73).

- $N(t+1,t)$ is number of deaths, and $P(t+1,t)$ is population between ages t and $t+1$.

- Survival probability between ages t and $t+1$ is calculated as:

$$S(t+1,t) = 1 - \frac{N(t+1,t)}{P(t+1,t)}.$$

- $NV(t+1,t)$ is number of deaths caused by violence between ages t and $t+1$.

- Counterfactual survival probabilities in the absence of violence are constructed as:

$$SNV(t+1,t) = 1 - \frac{N(t+1,t) - NV(t+1,t)}{P(t+1,t)}.$$

- *SNV(t+1,t)* gives the survival probability that would be observed between ages t and $t + 1$ if there were no deaths from violence.

- Observed and "no-violence" cumulative survival functions are:

$$S(t,a) = \prod_{a}^{t-1} S(i + 1, i),$$

$$SNV(t,a) = \prod_{a}^{t-1} SNV(i + 1, i).$$

- Observed and "no-violence" life expectancies are:

$$L = \sum_{t=1}^{\infty} S(t,0),$$

$$LNV = \sum_{t=1}^{\infty} SNV(t,0).$$

  ➜ Life Exp Lost to Violence $= L_v = LNV - L$

4. Results

- In Colombia, 2.2 expected years of life are lost due to violence. In Brazil, Chile, Croatia, El Salvador, Kazakhstan, Philippines amd Russia close to 1 year of life expectancy is lost to violence.

- For an eighteen-year old individual, MWP_{18} picks at around 4,300 for North America, followed by 2,900 for Latin America. These two cases illustrate the forces at work in determining the willingness to pay: income and mortality.

- North America has highest income and homicides above other developed countries. Latin America's income is second lowest, but homicide rates are the highest.

Table 1: Value of Violence Reduction and Descriptive Statistics, WHO Regions*, 1995

WHO Region	Life Expectancy	Hom. Rate (per 100,000)	GDP per capita	Life Exp with No Viol	Exp Years of Life Lost	MWP$_{18}$	Social Val (bill.)	Social Val % GDP
L America & Carib	71.4	21.8	7,708	72.0	0.6	2,941	43.07	27%
North America	76.1	6.5	25,672	76.3	0.2	4,389	496.61	8%
Western Europe	76.2	4.0	19,532	76.3	0.1	1,383	17.62	5%
East Europe	68.9	17.2	6,009	69.2	0.4	1,435	29.16	15%
Western Pacific	76.0	7.8	17,839	76.3	0.2	1,368	32.95	9%

Notes: * Regional numbers are unweighted country averages. Due to data availability, the only African country included in the sample is Mauritius, and the only Eastern Mediterranean country is Kuwait. Therefore, these regions are not included in this table. Values for these two countries are contained in Table 2.

- On average: 100% increase in income is associated with a $1,400 increase in MWP_{18}; and one additional year of life expectancy lost to violence increases MWP_{18} by $4,600.

- Average social cost of violence for Latin America: 27% of the 1995 GDP. This number is 100% for Colombia, 53% for El Salvador, 38% for Brazil.

- From the 10 highest values, 7 are Latin American, 2 are Eastern European (Kazakhstan, Turkmenistan, and Russia), and the remaining one is the Philippines.

- In the other extreme, 7 out of the 10 lowest values are from Western Europe.

- On average, one additional year of life lost to violence increases the social willingness to pay by 44% of the GDP.

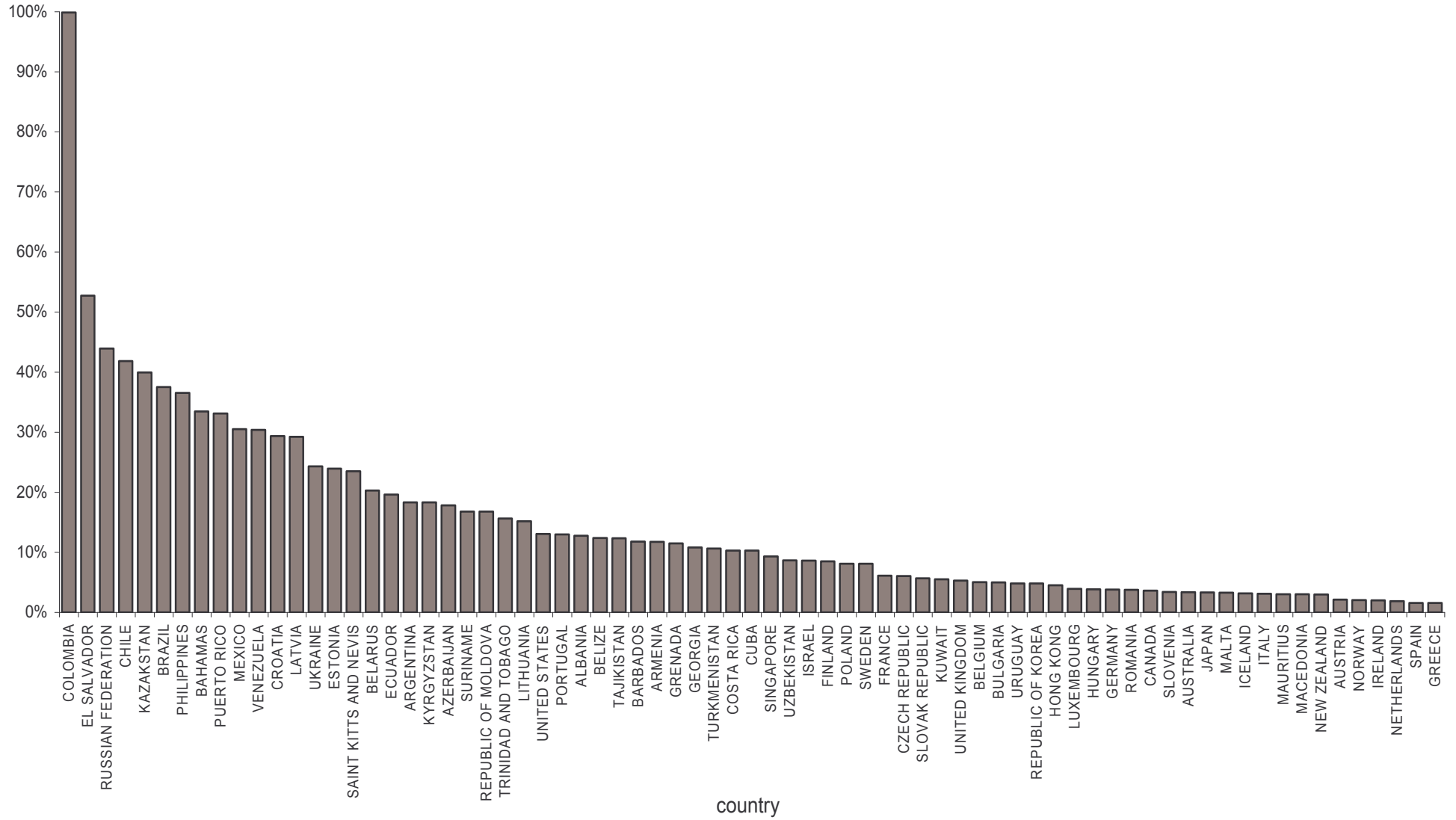**Figure 1: Social Value of Violence Reduction (% of GDP), 1995**

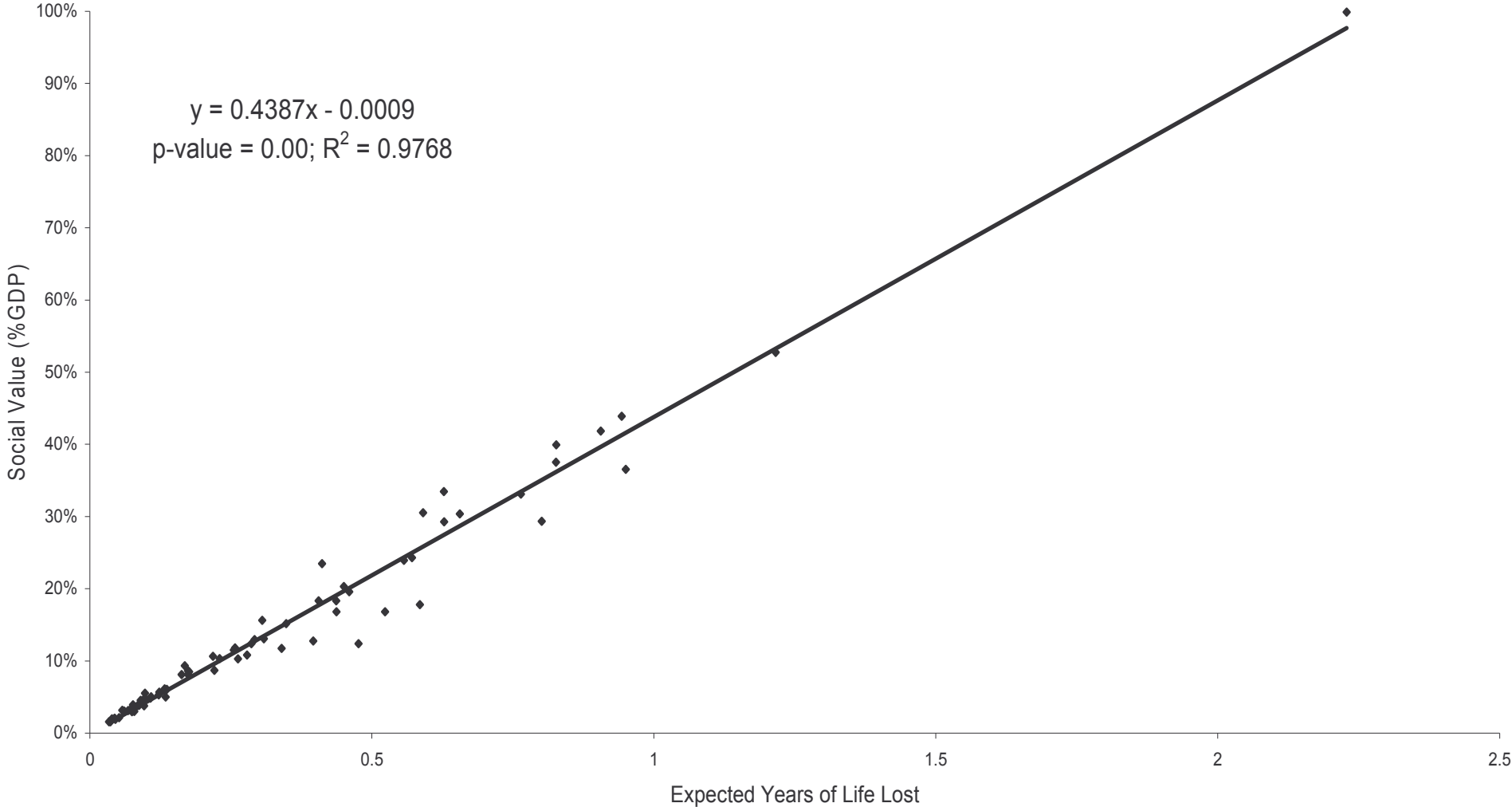**Figure 2: Expected Years of Life Lost and Social Value of Violence Reduction (% of GDP), 1995**

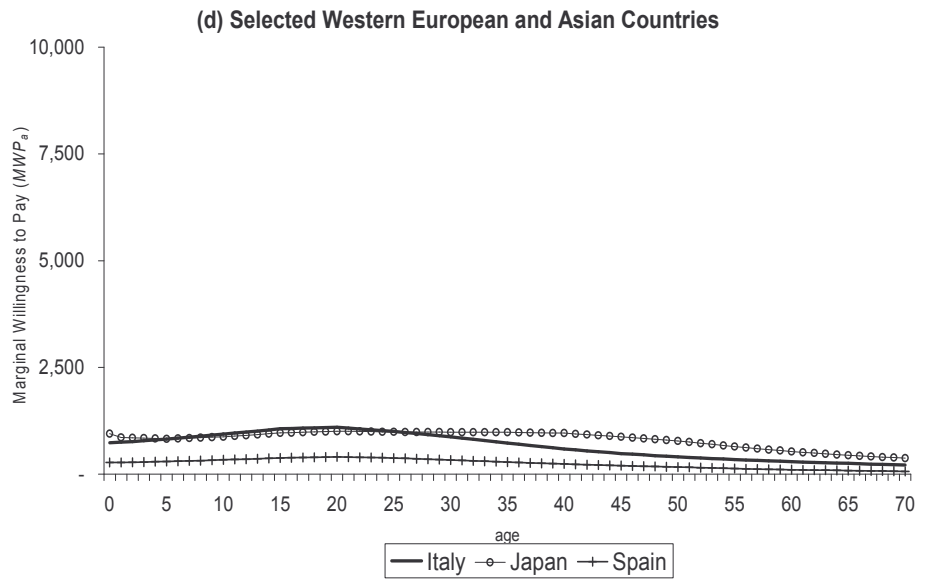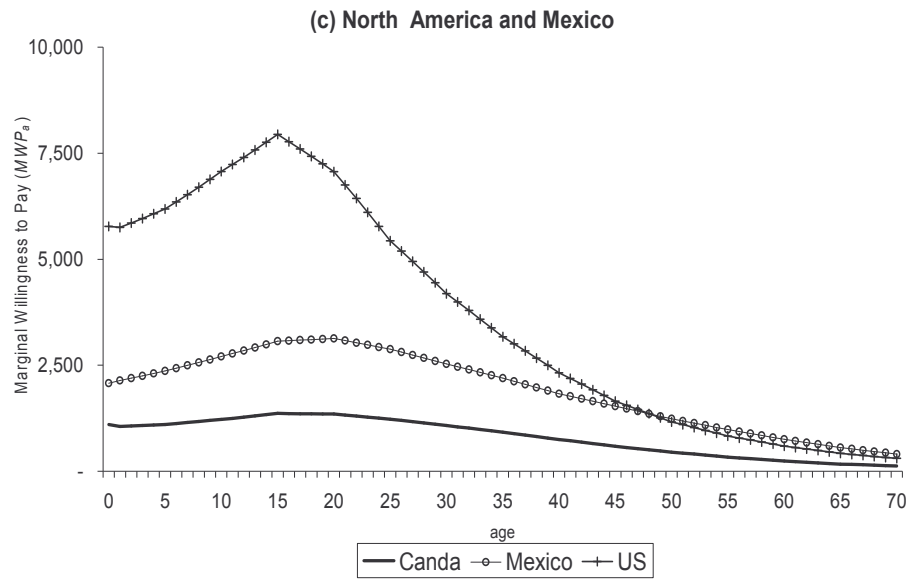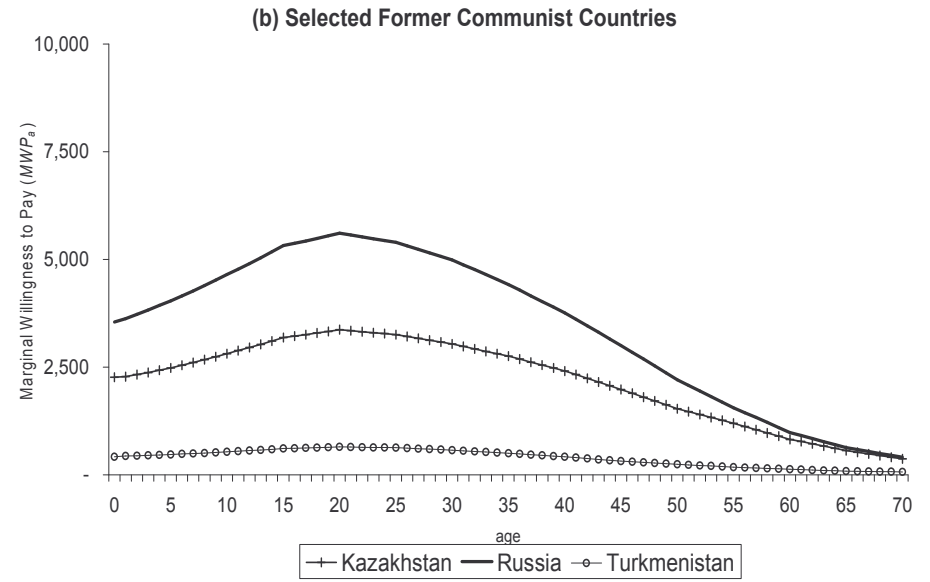$y = 0.4387x - 0.0009$
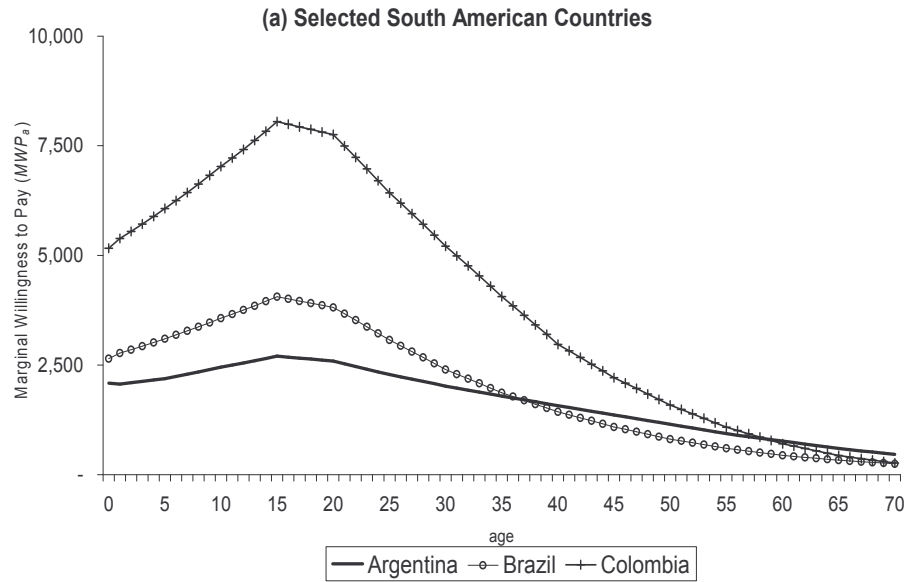p-value = 0.00; $R^2 = 0.9768$

Figure 3: Age Profile of the Willingness to Pay for Violence Reductions, Selected Countries, 1995

5. Inequalities in Income and Exposure to Risk

- Limitation of the methodology: implicit assumption that both income and victimization are equally distributed across population.

- Victimization rates of different crimes are typically correlated with several characteristics: socioeconomic status, gender, age, etc.

- In order to overcome this problem, we would need number of violent deaths and income broken down for each of these groups.

- In most of these dimensions, victimization and income move together (age and gender, for example), in which case our results would underestimate the cost of violence.

- But in one important dimension, this is not generally true: socioeconomic status.

- To assess the extent of this problem, we analyze an extreme case, in which the positive bias is likely to be the largest one: Brazil.

- Brazil has one of the highest levels of income inequality in the world (20% richest earn more than 30 times the income of the 20% poorest). In addition, Brazilian homicides rates are above 30 per 100,000 inhabitants, also among the highest in the world.

- Brazilian Ministry of Health releases statistics on number of violent deaths by 4 educational levels (large number of missing obs): "No Education" (0 years of schooling), "Some Elementary" education (between 1 and 8 years), "Some High-School" (between 9 and 11 years), and "Some College" (more than 11 years).

- Income per capita within each educational group calculated based on wage differentials, and distribution of population simulated according to the labor force distribution (Menezes-Filho, 2001).

Table 4: Descriptive Statistics for Educational Groups, Brazil, 1995

Educational Group	Income per Capita	Homicide Rate	Population Share
No Education	2,706	35.4	13%
Some Elementary	4,006	68.5	35%
Some High School	6,689	4.8	43%
Some College	20,469	8.1	10%

Note: Income per capita is GDP in 1996 international prices adjusted for terms of trade, calculated using average educational wage differentials. Population shares are calculated using shares of the labor force.

Table 5: Value of Violence Reduction by Educational Group, Brazil, 1995

Educational Group	Life Expectancy	Expected Years of Life Lost	MWP_{18}	Social Value (billions)	Social Value % GDP
No Education	68.7	1.1	1,341	11.6	1.8%
Some Elementary	68.0	1.8	4,498	94.2	14.6%
Some High School	69.7	0.1	673	17.8	2.8%
Some College	69.6	0.2	4,025	28.8	4.5%
Aggregate Social Cost of Violence =				152.4	23.7%

- Homicide victimization is largely concentrated among the less educated/poor: rates for "Some Elementary" education are more than 8 times higher than rates for "Some College."

- At the same time, people with "Some College" earn on average 5 times more than people with "Some Elementary" education.

- This leads to an overestimation of the social willingness to pay for violence reductions.

- Once income and victimization inequalities are taken into account (assuming that mortality by the other causes is the same across educational groups), the social cost of violence is estimated to be 24% of the 1995 GDP, as opposed to 38% estimated before. The estimated social cost is reduced by roughly 37% of its initial value.

- Most of the burden of violence falls on the population with "Some Elementary" education:

  → 35% of Brazilian population (most of the urban poor);

  → 1.8 years of life expectancy at birth lost due to violent deaths;

  → Aggregate MWP = 15% of the 1995 Brazilian GDP.

- "No Education" group has very low income and, therefore, its willingness to pay is quantitatively small, even though it is exposed to very high homicide rates.

- "Some High School" and "Some College" have higher incomes, but are exposed to lower violence levels and are smaller in size.

- 37% bias is likely to be close to an upper bound (extreme case).

Figure 4: Willingness to Pay for Violence Reductions by Age and Educational Groups, Brazil
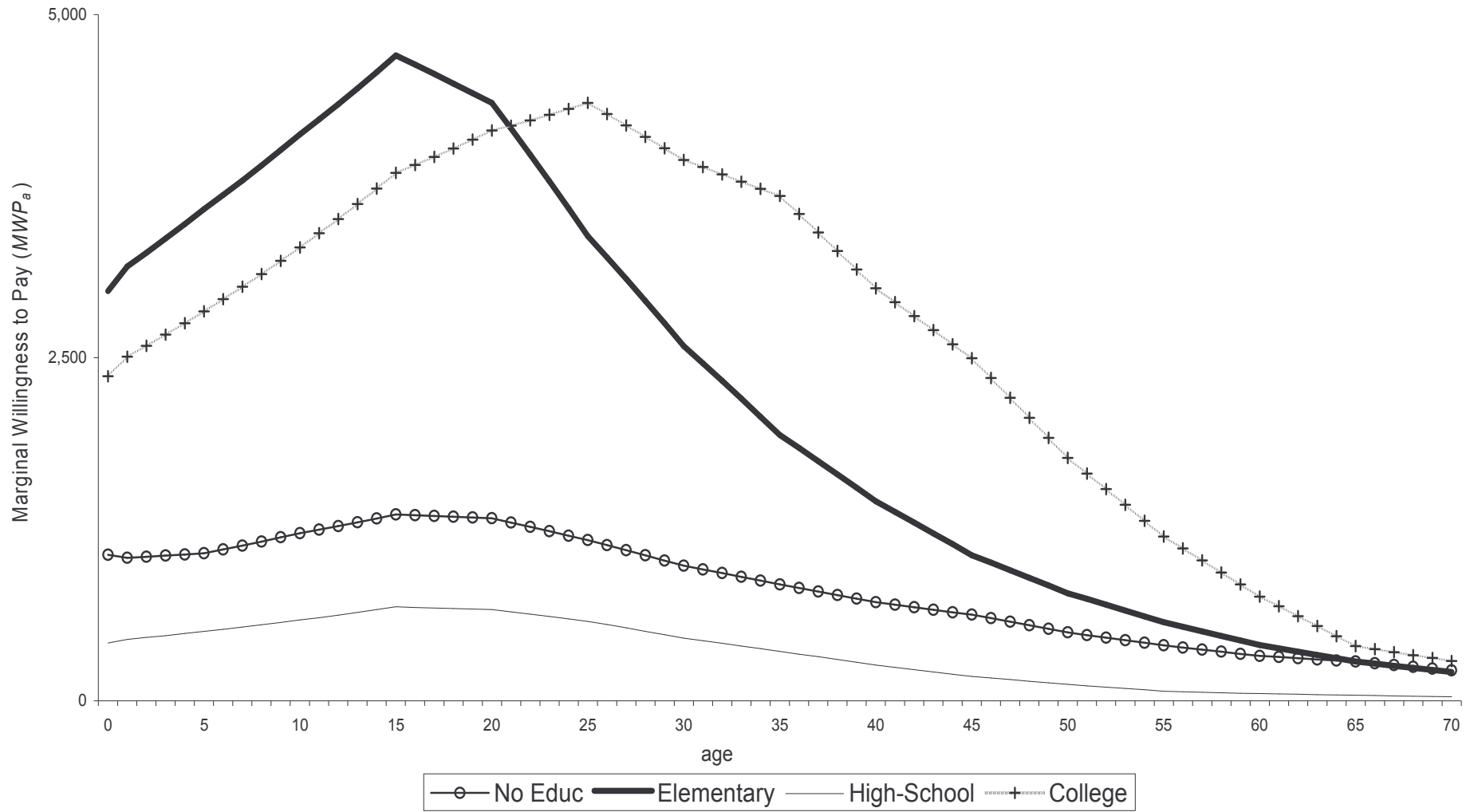
6. Concluding Remarks

- Paper presents the first comprehensive cross-country assessment of the importance of non-monetary costs of violence.

- The estimated welfare cost of violence from mortality increases is of the same order of magnitude of the present discounted value of the annual flow of material costs of crime (62% of the GDP for the US and roughly 100% for Latin America).

- Indirect effects of reduction in life expectancy would increase the total costs even further (reduced investments in HK, health, savings and investments in physical capital).