Assessing São Paulo´s Large Drop in Homicides: The Role of Demography and Policy Interventions

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Abstract

After reaching a historic peak by the end of the 1990s, homicides in the São Paulo Metropolitan Area (SMPA) dropped sharply in years 2000s. In this paper we list the most credible causes and assess critically their roles in explaining the large shift in homicides. We document several facts: 1) the scope of the movements in homicides is not restricted to SPMA, including other large cities in the State of São Paulo; 2) several policy changes possibly contributed to the drop in homicides in the 2000s in SPMA, but their timing exclude them as an explanation for the sure in the 1990s and for the shift in homicides in the late 1990s; in addition, 3) their narrow geographical scope exclude them as an explanation for the broad geographical movements in homicides; 4) economic conditions may have contributed to the increase in the 1990s but cannot account for the late 1990s shift; 5) age structure had a significant impact on homicides; 6) the time-series pattern of homicides in other states is similar to São Paulo´s, providing further support for a common-component explanation.
KEYWORDS: Age Structure, Demographic Change, Homicides

1. Introduction

The São Paulo Metropolitan Area (SMPA) has received significant attention in the domestic and international media for its sharp swings in homicides during the years 1990s and 2000s.[1] After increasing steadily over the 1990s, homicides fell sharply in the 2000s. There were 24 homicides per 100thd inhabitants in 2005 at the SPMA, down from 52 in the 1999 peak, and 20% *less* than the level in the early 1990s. The dynamics are similar to large American cities, where homicides peaked ten years before. Figure 1 summarizes the motivation for this paper. Although the spotlight was always on the SPMA, homicides movements are similar across the board.[2] One can see considerable cross-city variation in levels but the dynamics of homicides is remarkably similar across cities.

Fig. 1 Homicides in the State of São Paulo
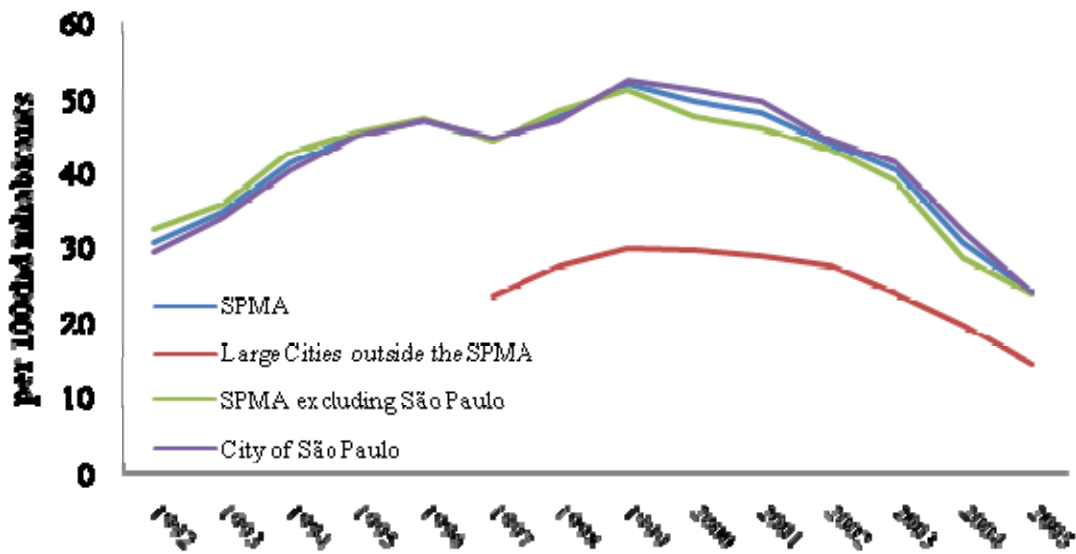
Source: Secretaria de Segurança de São Paulo

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[1] In the last three years the British weekly newspaper *The Economist* twice reported twice on the murder trends in São Paulo (*Protecting citizens from themselves*, Oct 20th 2005 and *Not as violent as you thought*, Aug 21st 2008)

[2] Specific graphs for all cities with more than 100thd inhabitants are available upon request.

This paper assesses the causes behind this large shift in homicides. It is composed of 6 sections including this introduction. Section 2 describes the data sources. Section 3 is descriptive and provides an overview of the evolution of crime not only in São Paulo but in Brazil in general. We show three important facts. First, the homicide phenomenon is a peculiarity of the 1990s and 2000s. Homicides were flat or only slightly increasing before they surged in the 1990s. Second, crime rates also dropped in other categories, suggesting a common component across crime categories. Finally, homicides follow a similar trend in the rest of Brazil, with a three-to-four year lag, again suggesting a common component across regions. In section 4, we assess a long list of suspects. Improvements in policing occurred. The most important are: 1) the adoption of a unified data and intelligence system (INFOCRIM, a version of *Compustat*); 2) the implementation of a photo database of criminals; 3) and the cracking down on illegal firearms possession. Incarcerated population also increased over the period. Among municipal-level policy measures, several others are worth mentioning: the adoption "dry laws" (which are restrictions on the recreational sales of alcohol), the creation of municipal police forces, and the adoption of DISQUE-DENÚNCIA (anonymous hotline to report crimes). See Kahn and Zanetic [2005].[3] Finally, the state of São Paulo cracked down on illegal gun possession, which might have contributed to the reduction in homicides (Goertzel and Kahn (2007)).

Homicides dropped more sharply in São Paulo than in the rest of the country, which suggest that the policies helped to reduce homicides. However, they fail to account for the timing of the reversal in the late 1990s because homicides had been dropping for at least a couple of years *before* the first policies were implemented. Consider the "Dry laws". Their adoption is not nearly as broad as the drop in homicides. In addition the timing does not match: in all but one city, adoption occurred *after* 2001. Evidence shows that they did cause a non-negligible reduction in homicides, but they are only a contributing factor, strengthening a trend that was already in place.[4] Another good example is INFOCRIM. The system was first implemented in the city of São Paulo in

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[3] From 2003, the "Disarmament Act" (Lei do Desarmamento, Lei Nº 10.826) is a federal act that increased significantly the penal and civil costs of illegal possession and trade of fire guns. See http://www.camara.gov.br/internet/infdoc/Publicacoes/html/pdf/Desarmamento.pdf

[4] By comparing homicide dynamics in adopting and non-adopting municipalities in the SPMA, Biderman et al [2009] estimate that "dry laws" caused a reduction of roughly 12% in homicides.

2000, then in the rest of the SPMA. Outside the SPMA, implementation started only after 2005.

In section 4 we provide evidence on the demographic explanation. In contrast to other candidates, demographics rationalize not only the decline in the 1990s, but also the surge in homicides in the 1990s. Furthermore, and again in contrast with other explanations, demographics explains not only the dynamics of homicide in São Paulo, but also in the rest of the country. Homicides peaked in São Paulo in the late 1990s, just as the population aged 15-24 also peaked. In the rest of the country, homicides and the population aged 15-24 peaked a few years later.

Section 5 concludes the paper with a brief discussion. The case of São Paulo is particularly interesting when compared with the US experience. Zimiring (2007) shows that the large shift in crime in late 1980s – early 1990s was not confined to New York (the most publicized case), but occurred across the board in the U.S. However, New York stands out. The analogy with São Paulo and Brazil is immediate. In the case of São Paulo, the increase and drop in homicides is widespread *within* the state and throughout the country. Also in line with the American case, several factors help to explain the decline of homicides in the 2000s. However, only demography also rationalizes the decline of homicides in the 2000s *and* the surge in the 1990s. Analogously to New York, the decline in São Paulo has been (so far) more pronounced than in the rest of country. Finally, Zimiring (2007) analyzes data from Canada and shows a remarkable similarity between American and Canadian crime trends, suggesting a common component explanation. In Zimiring (2007) own words:

> "*But what joint causes might have operated in Canada and the United States throughout the 1990s? This uncomfortably open question is of obvious importance to **rethinking** the causes of the U.S. decline…What would explain the 30% or so of slow and steady decline over the nine years following 1991 in the United States and Canada? The **only** traditional theory of decline supported by parallel U.S. and Canadian data trends is the **decline of high-risk age groups as a percentage of the population**. But even if all the decline in youth share of population*

that occurred both in 1980s and 1990s is counted toward the crime decline that was confined to the 1990s, it would be difficult to find many criminologists who would expect that feature alone to produce a crime decline greater than 10%, and even that 10% should have been spread more evenly across two decades in both countries.

*[But **the demographic similarity**] between Canada and the United States over the period 1980 onwards invites, if it does not **demand**, a reconsideration of the magnitude of age structure effects on crime."[5]*

We accept Zimiring's invitation to reconsider the magnitude of age structure effects. Using data from São Paulo, we recover a very large elasticity of homicides to changes in the size of the 15-to-24 year old population. The criminologists' difficulty in considering the demographic explanation is based on the conventional wisdom that age structure effects are small. The similarity between the U.S. and Canada, and our estimates for São Paulo, demands a reconsideration of the magnitude of elasticities.

2. Data

We use several sources of data. The city-level homicide data for the state of São Paulo come from the Secretaria de Segurança Pública de São Paulo (*Secretaria*), the state-level enforcement authority. Although hospital data is available, we prefer police report. Geographical location of hospital murder data is tricky at the city level, since the murder victim may be taken to a hospital in another city (is it much less likely that victims will cross state lines).

Data on other crime categories are also from the *Secretaria*. Crime data in Brazil is limited when compared to the US and Canada. Reliable police crime data are not available for a long period in Brazil. São Paulo has consistent police report data for some categories since 1984, which allows some backward look at the evolution of crime by categories. For the rest of the country we use hospital data from DATASUS, which have the same consistent categorizations since the mid 1990s.

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[5] Our emphasis.

For states other than São Paulo, no consistent series for crime categories other than murder is available. For São Paulo we have data dating back to 1984. Even for São Paulo, using data from crime categories other than homicide is a tricky business. As Biderman et al (2009) put it "Most crime statistics suffer from serious under-reporting in Brazil, stemming from historical lack of confidence in authorities. Under-reporting *per se* does not invalidate the use of other categories, but extra caution must be exercised because reporting improved over the sample period. Institutional innovations in the state-level bureaucracy reduced the costs of reporting. Among them are: i) the creation of *Poupa-Tempo*, whose claque is "time-saver", which are offices where all bureaucratic errands, including reporting crimes, may be done; ii) *Delegacia Eletrônica* (electronic police station) for on-line reporting; and iii) *Delegacias da Mulher*, police stations specialized in domestic violence." The "sample period" in Biderman et al (2009) is roughly similar to our period of analysis.

State-level murder data come from DATASUS, the hospital database of the National Ministry of Health. Although the data go back quite a long time, the taxonomy of violent deaths changed in 1996.[6] Thus, for estimating the state-level panel model we use data from 1996 onwards in order to keep consistency of observations across time.[7] For depicting national aggregates, when inconsistency is less costly, we use data from 1991. Also from DATASUS are data on the age distribution of homicide victims.

Demographics are from the Instituto Brasileiro de Estatística e Geografia (IBGE), the Brazilian equivalent of the Bureau of Statistics. For census years (1991 and 2000) full population counts by age-groups are available. For non-census years in the 1990s, and for all years at the city level, population by age-group is projected based on the 1991 and 2000 census, and the population counts of 1996 and 2007.[8]

Data on the age distribution of perpetrators is from the Secretaria de Justiça do Estado de São Paulo, the state-level equivalent of a Department of Justice. Finally, we

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[6] From 1996 onwards, the system of morbidity taxonomy has been the 10th International Classification of Diseases (ICD-10), which substituted the previous system (the ICD-9). Differences in classification for deaths by external causes exist and the Brazilian ICD-9 and 10 series are not compatible with each other. More details can be found at the World Health Organization website at http://www.who.int/classifications/icd/en/

[7] Elasticity estimates are similar if the series is extended back to 1991.

[8] Results are similar if for the 2000s use projections based on the 2000 census and the 2007 population count.

use two victimization surveys for the city of São Paulo, both conducted by the Instituto Futuro Brasil (IFB), a São Paulo-based think-tank. One was conducted in 2003 and another in 2008. Results are comparable over time.

## 3. Taking a wider look: other crimes in São Paulo and Homicides across the Country

This section provides a wide overview of crime in São Paulo and the rest of the country. A wide view puts the dynamics of homicide in São Paulo into perspective. With data dating from before the mid-1990s we may judge whether the 1990s-200s crime shift is in fact a peculiarity. Data from other crime categories, and data from other states, allow us to assess how widespread the movements in crime are.

3.1 Looking Backwards and at other Categories

We start by showing some long trends of several crime categories in SPMA. Data dates back to 1984.[9] Figures 2 through 5 show four categories: homicides, assault, common robbery and theft, and vehicle robbery and theft. The important distinction between vehicle and common theft (everything but vehicle) is under-reporting. While common robberies and thefts are severely under-reported, vehicles are quite well measured because of insurance and legal liability reasons (see Biderman et al (2009)).

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[9] Data from before the 1990s is only available for the SPMA.

Fig. 2 Homicides per 100thd Inhabitants
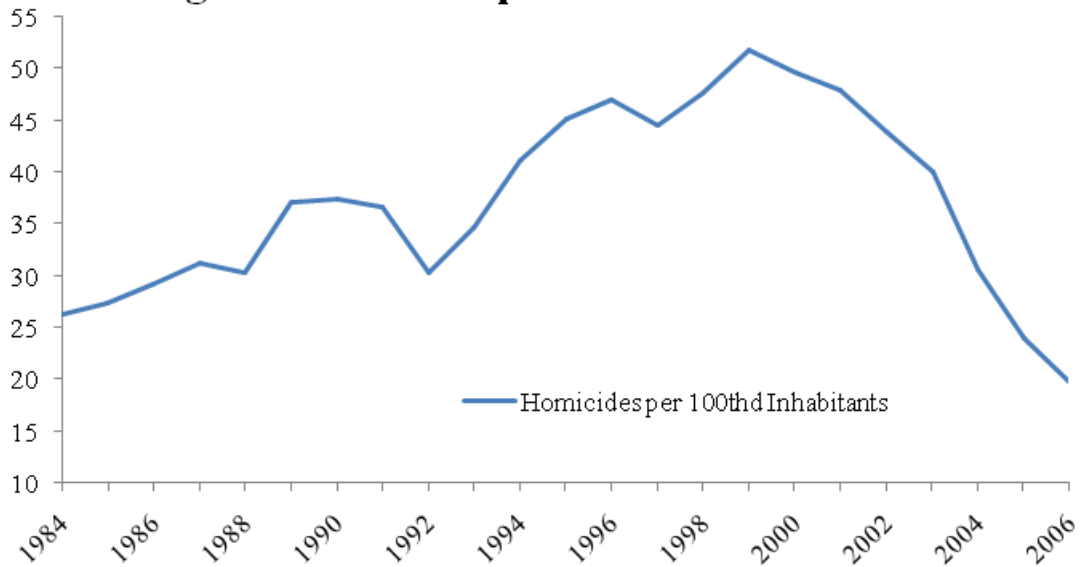
Source: Secretaria de Segurança Pública de São Paulo (SSP-SP)

The big surge in homicides is mainly a phenomenon from the 1990s. Although homicides were picking up since the mid-1980s, neither pace of increase nor the consistency is comparable to 1990s. Furthermore, the decline in homicides in the 2000s is also an unprecedented phenomenon.

Fig. 3 Assault per 100thd Inhabitants

Source: Secretaria de Segurança Pública de São Paulo (SSP-SP)

Assaults, if anything, follow a pattern symmetrically opposite to homicides. However, under-reporting of assaults changed over time. Consider *Disque-denúncia*, an anonymous hot-line to report crime. Anecdotal evidence suggests that *Disque-denúncia* improved reporting of assaults (see Kahn and Zanetic (2005)). Figure 4 shows data from the two victimization surveys conducted in city of São Paulo in 2003 and 2008. Panel A contains information on the victimization. In 2003, 4% of respondents declared they had been a victim of assault in the previous 18 months. In 2008, the figure drops to 2.7%, a 33% reduction (the difference is statistically significant at the 1% level).

Panel B contains information on reporting by victims. In 2003, 29% of victims of assault that "called or informed", and 23% filed a complaint (which implies a police report is generated). In 2008, these percentages were 34% and 27.5%, respectively. In summary, victimization data suggest that assaults dropped in 2000s, in line with the pattern of homicides. For the 1990s, data is inconclusive because of time-varying under-reporting.

Fig. 4, Panel A Assault
% reporting being victims of assault in the previous 18 months

Source: Inistuto Futuro Brasil (IFB)

Fig. 4, Panel B % Reporting Assault
By Categories

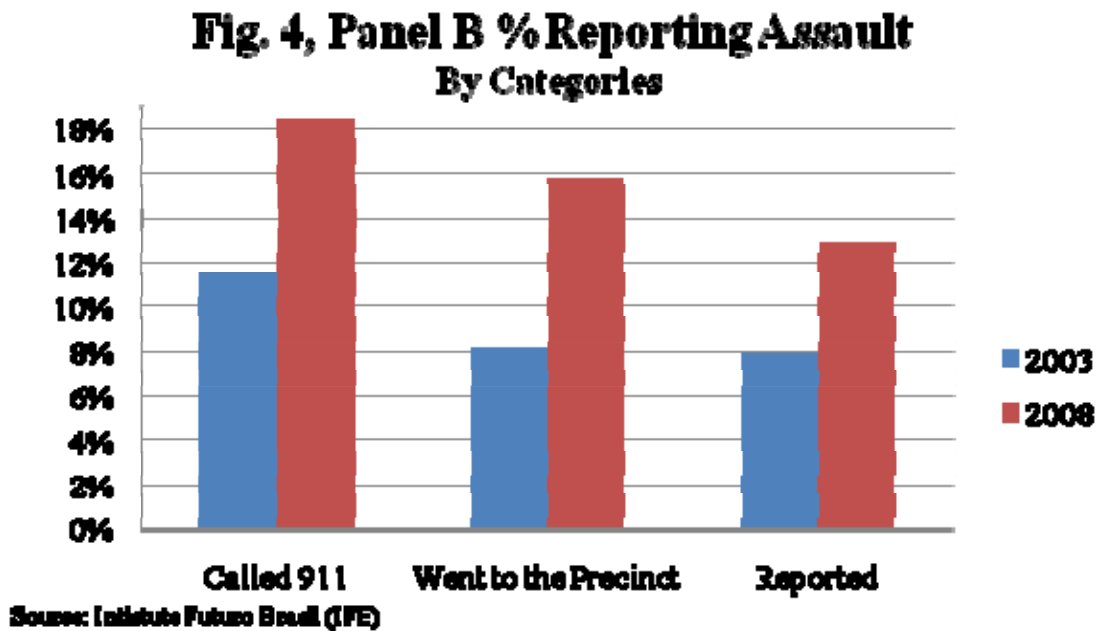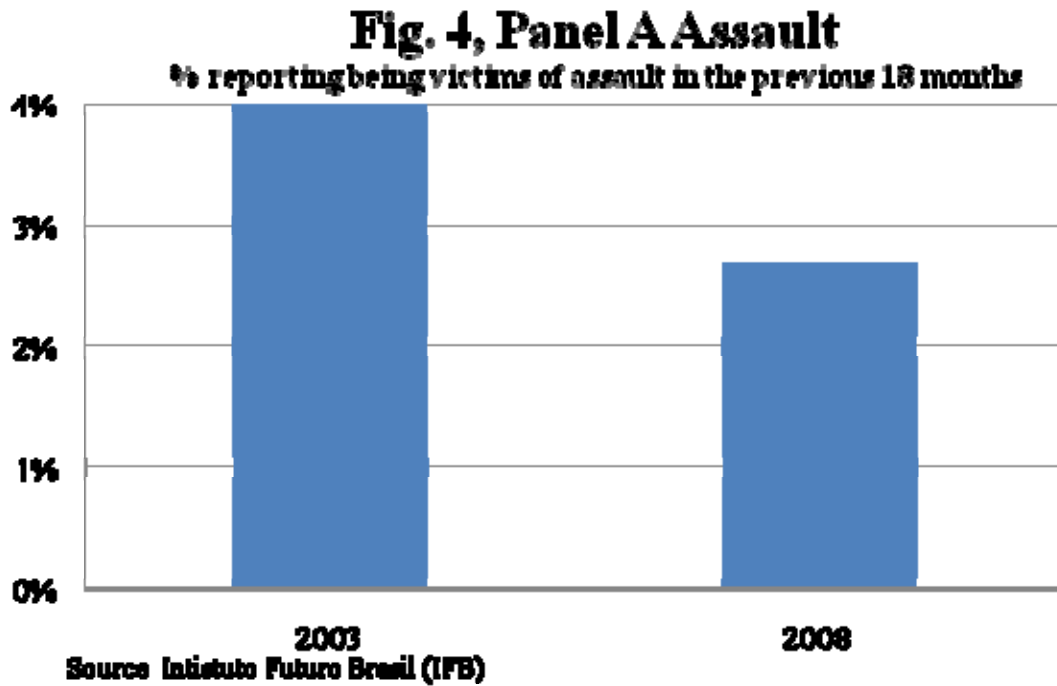Source: Inistuto Futuro Brasil (IFB)

Figure 5 shows data on thefts and robbery. We present two separate categories: vehicle and everything else (common). Vehicle theft and robbery resembles the dynamics of homicide. They surge in the 1990s, reach a peak in the around 1999-2000 and then

decline monotonically. Common robberies and thefts also surge in 1990s. In contrast to vehicles, they do not peak in the late 1990s. In fact, data suggest the stabilized at the high late 1990s plateau. Again, however, data is not informative because of improvement in reporting in the 2000s.
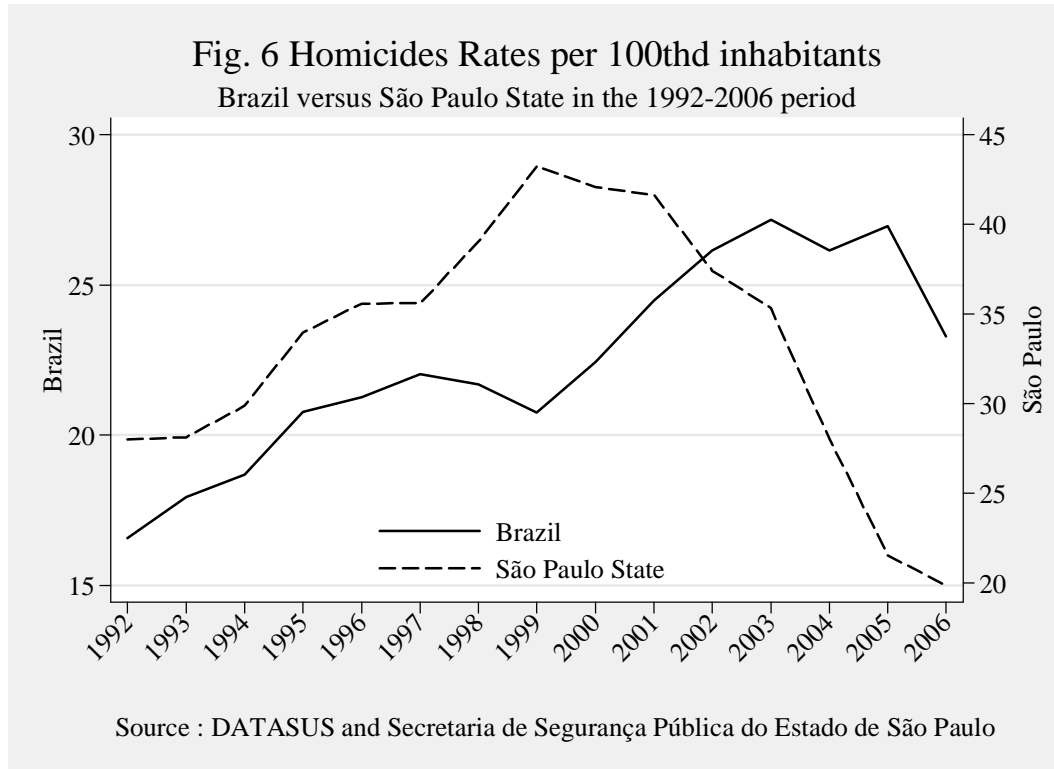
Fig. 5 Robbery and Theft
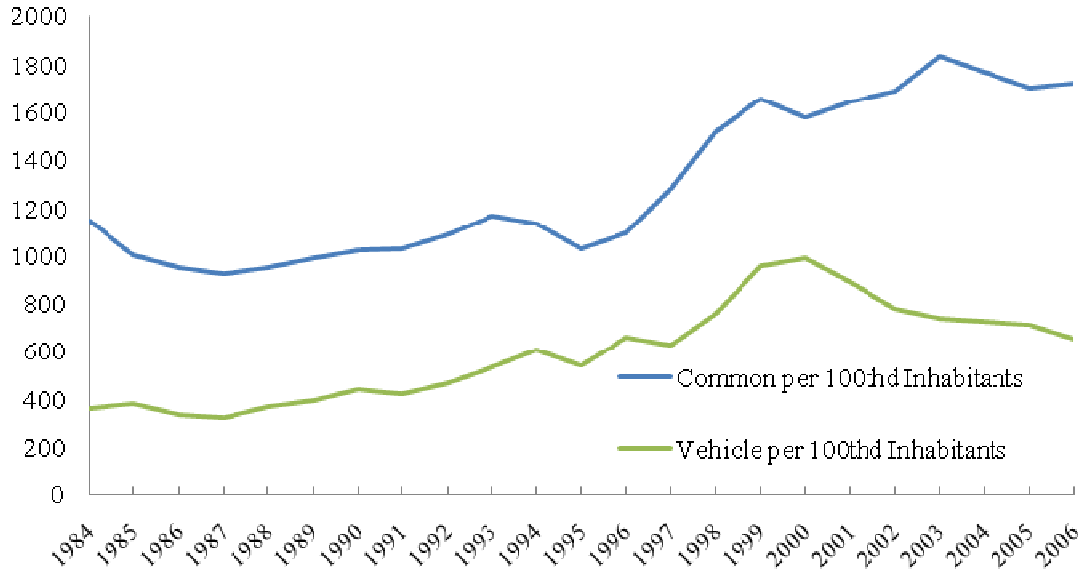
Source: Secretaria de Segurança Pública de São Paulo (SSP-SP)

In summary, different well-measured crime categories show that crime in general surged in the 1990s and then dropped in 2000s, suggesting a common component explanation.

3.3 The Rest of Brazil

Figure 6 shows the evolution of homicide rates in São Paulo *vis-à-vis* the rest of the country.

Fig. 6 Homicides Rates per 100thd inhabitants
Brazil versus São Paulo State in the 1992-2006 period

Source : DATASUS and Secretaria de Segurança Pública do Estado de São Paulo

Brazil is São Paulo with a three-to-four-year lag. The increase of homicides during the 1990s was remarkably similar in São Paulo and in the rest of Brazil. The two series reached a peak in different yet reasonably close moments in time: while homicides in São Paulo peaked around 1999, in Brazil the peak was in 2003. From the peak, homicides dropped much faster in São Paulo, possibly reflecting a peculiarity in terms of policies implemented, or perhaps little time has passed since the peak in the whole country.

Aggregate figures may hide important local heterogeneity that may be incompatible with a common component explanation. Figure 7 shows the evolution of homicides in several Brazilian states. Although some heterogeneity exists, the co-movement in homicides is remarkable, reinforcing the idea of a common component.[10]

Consider the state of Rio de Janeiro. It experiences a big surge in homicides in the first half of the 1990s, a (still unexplained) phenomenon that made the state infamous for its violence. Homicides decline afterwards, just to increase again in the late 1990s –early

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[10] We show only the most important states in terms of population. Figures for other states are available upon request.
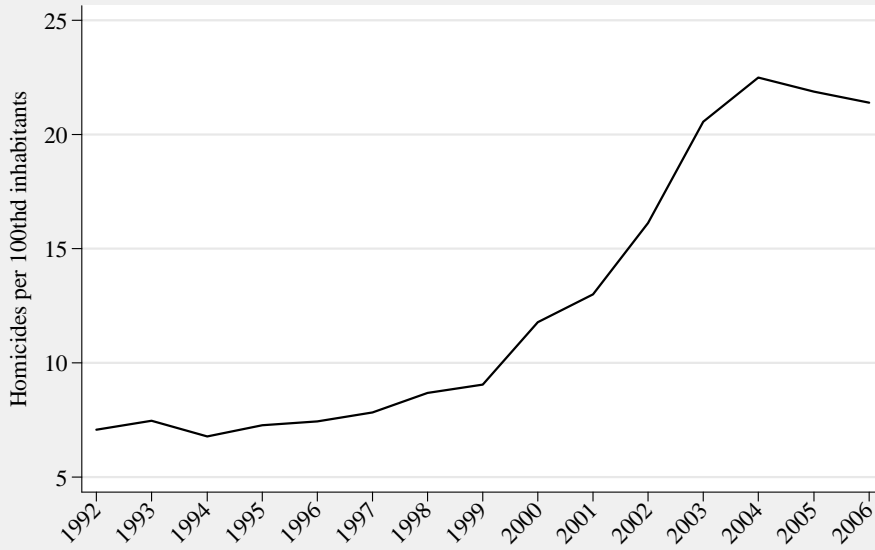
2000s. After 2002 they start to decline consistently. If one is prepared to consider the early 1990s surge a sporadic event, homicides in Rio follow the same pattern as the aggregate for Brazil (figure 6).

All other states depicted in figure 7 show a familiar pattern. Homicides increase almost monotonically in the 1990s. In all cases, homicides stabilize in the early-to-mid 1990s and then start to decline with different intensity. In summary, data from other states in the country show two things. First, homicides have strong co-movement across states, suggesting a common explanation. Second, the decline in the rest of Brazil starts later than in São Paulo.
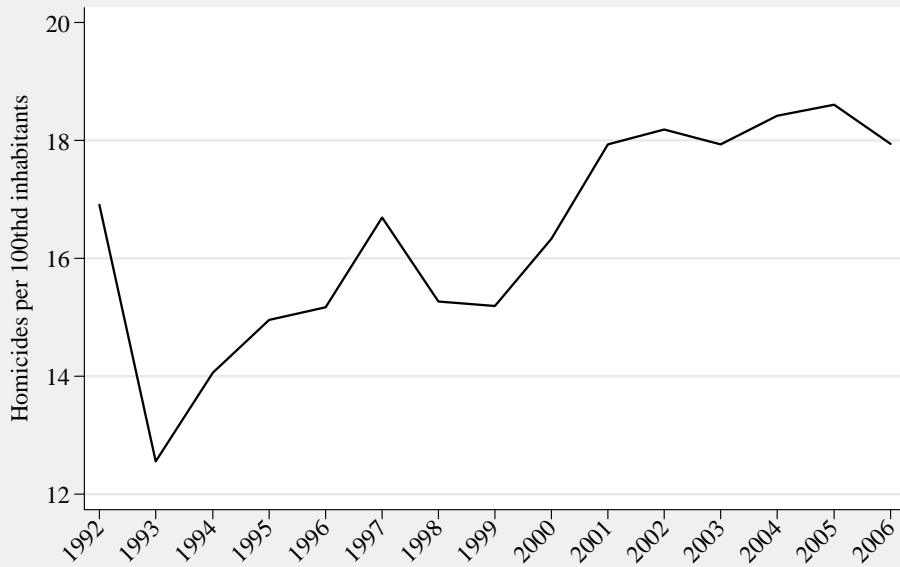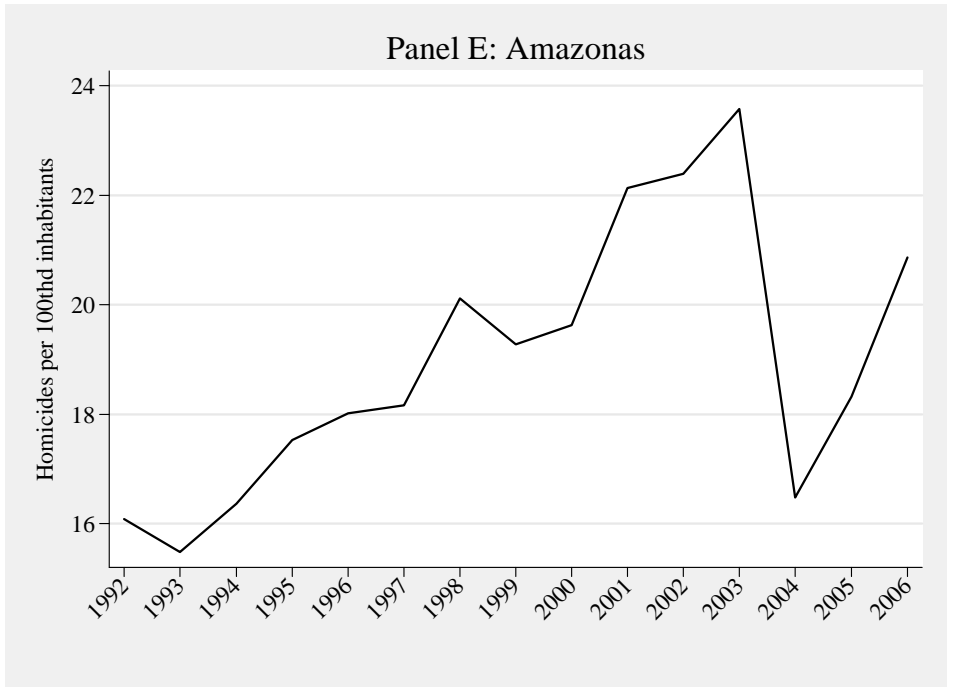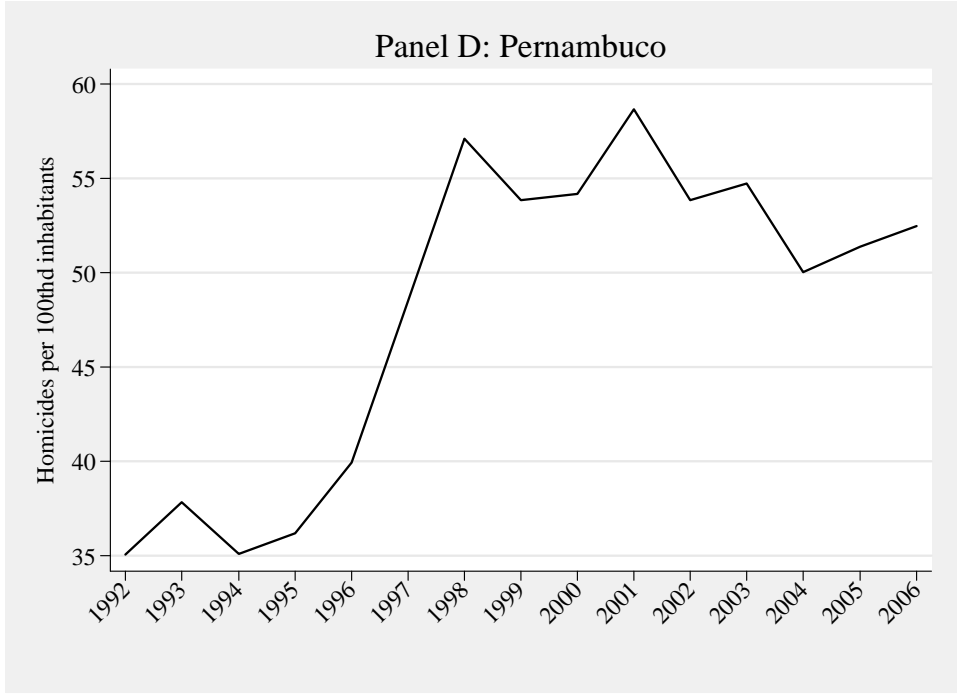
Fig. 7 Evolution of Homicides across States

Panel A: Rio de Janeiro
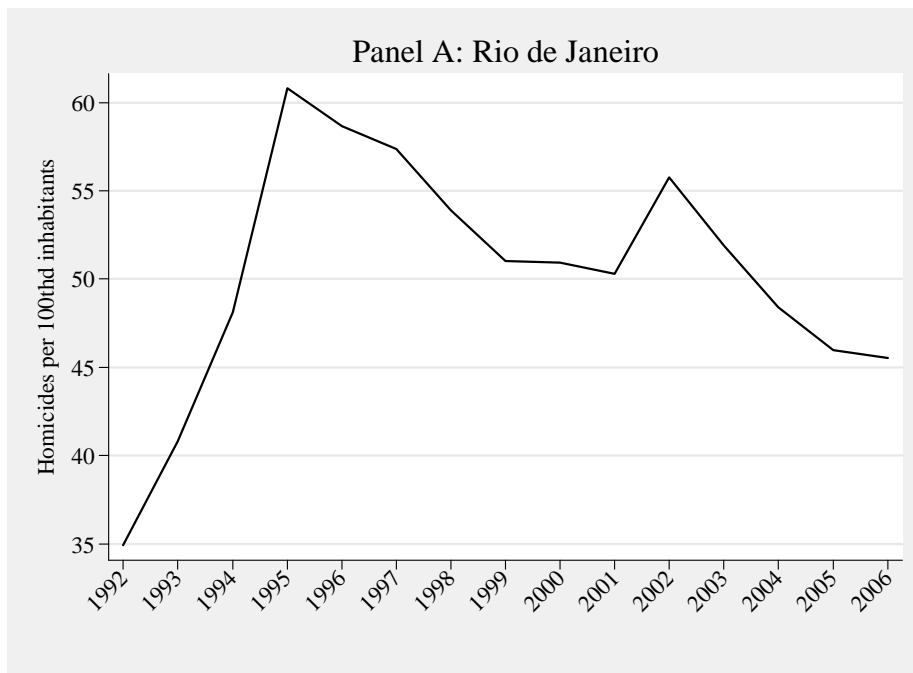
Panel B: Minas Gerais

Panel C: Rio Grande do Sul

Panel D: Pernambuco

Panel E: Amazonas

Panel F: Goiás
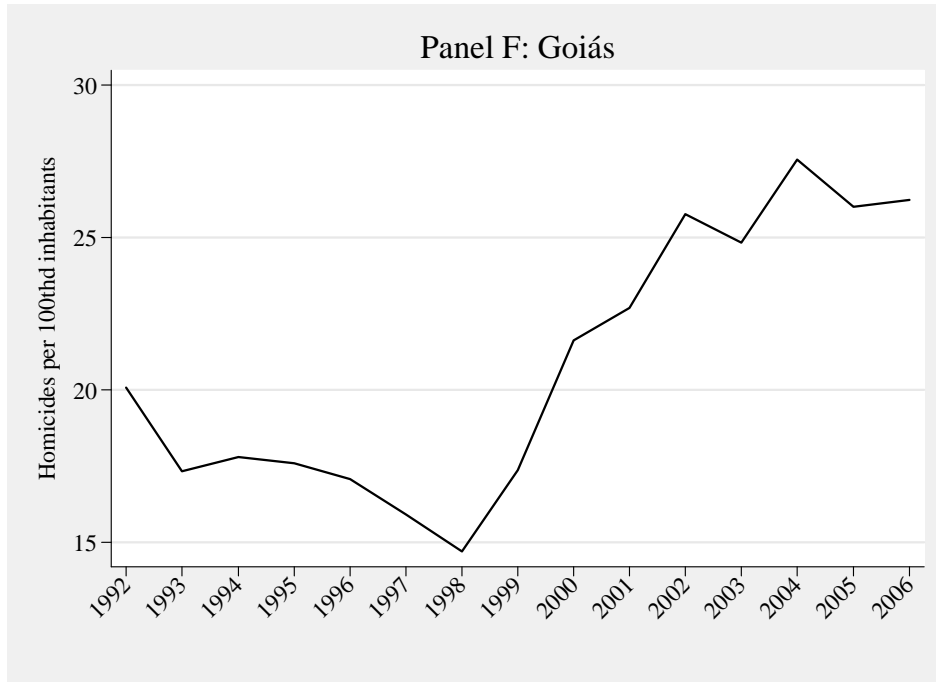
Source: DATASUS and Instituto Brasileiro de Geografia e Estatística (IBGE)

4. Possible Culprits: Police, Guns, Incarceration, Arrests…

As a reaction to the surge in crime during the 1990s, São Paulo implemented major policy interventions, both at the municipal and the state level. In this section we consider these policy interventions as explanations for the large shift in homicides in the state of São Paulo.

4.1 Police and Policing

Anecdotal evidence in press stories suggests that the reduction in crime during the 2000s is a consequence of years of well-conceived and well-executed crime-fighting policies. In this sub-section we assess the potential contribution of these policies.

As expected, policy reacted to the rise in homicides during the 1990s. Table 1 lists the most relevant police-type policies adopted from the second half of the 1990s through 2007.

Table 1 Policy Interventions

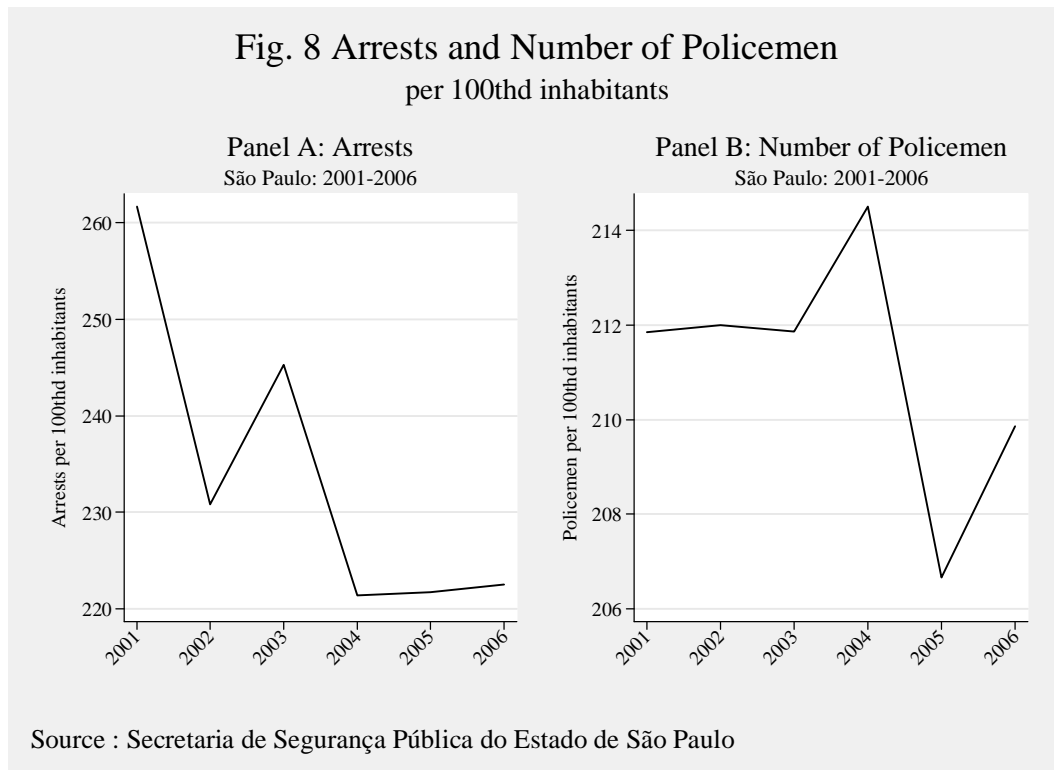| Policy	Level	Date
Creation of INFOCRIM, a database system of crime geo-referencing	SPMA and large cities	1999[A]
Executive order linking number of police officer to INFOCRIM	SPMA and large cities	2007
Creation of DISQUE-DENÚNCIA, a anonymous crime hotline to denounce crime	State	2000
Creation of FOTOCRIM, a database of pictures of wanted and in prison	State	1999
Effective implementation of FOTOCRIM as an instrument of photograph identification	State	2002
Elaboration of the Plano de Combate aos Homicídios, with emphasis on capturing repeated murderers	State	2001
Creation of a Municipal Police Forces	SPMA[B]	1962-2003[C]
"Operação Saturação", a centralized, systematic and permanent operation in drug-trafficking areas	State	2006

[A]: 1999 is the inauguration in the city of São Paulo. INFOCRIM starts to expand to other cities in SPMA in 2002. Other large cities in the state enter the system in 2005. See Biderman et al (2009).

[B]: 26 out of the 39 cities that form the SPMA have Municipal Police Forces

[C]: 7 Municipal Police Forces were created after 1998

Source: Kanh and Zanetic (2005) and Biderman et al (2009)

Most likely, all policy interventions had an impact on crime. The presence of a *Compustat* system such as INFOCRIM helps law enforcement. Nevertheless, it is difficult to imagine that interventions can account for the dynamics of homicide in the state of São Paulo. One reason is timing. All policy interventions occurred either exactly when the trend in homicides have been reversed (1999-2000), or afterwards. Although INFOCRIM was implemented in 1999, it became fully operational only in 2001, and data has not been used to determine local police force until recently.

Figure 8 shows the number of police and arrests. Unfortunately we only had data starting in 2001 on both variables. Nevertheless, the numbers are still informative. In panel A has arrests. From 2001, arrests dropped from 260 to 220 per 100thd inhabitants, a 15% decline. If an increase in severity or in the efficiency of police work explained the

decline in crime during the 2000s, one should see the opposite: arrests should be increase over the period. The fact that arrests *decline* in the period most likely reflects reverse causality: declining crime reduces arrests.

Panel B has the number of policemen. The scale makes the series seemingly volatile. In fact, the number of policemen stayed constant over the period. Thus, a big quantitative increase in police cannot explain the large reduction in crime during the 2000s. Of course, police quality may have improved but most interventions that improved police work occurred only later in the decade, and cannot explain the timing of the shift in homicides (see table 1).

Fig. 8 Arrests and Number of Policemen
per 100thd inhabitants

Source : Secretaria de Segurança Pública do Estado de São Paulo

4.2 Incarceration

Figure 9 shows the prison population per 100,000 inhabitants in the state of São Paulo from 1994 through 2006 (period of data availability).

Fig. 9 Incarceration Rates
São Paulo: 1994-2006

Source: Secretaria da Administração Penitenciária do Estado de São Paulo
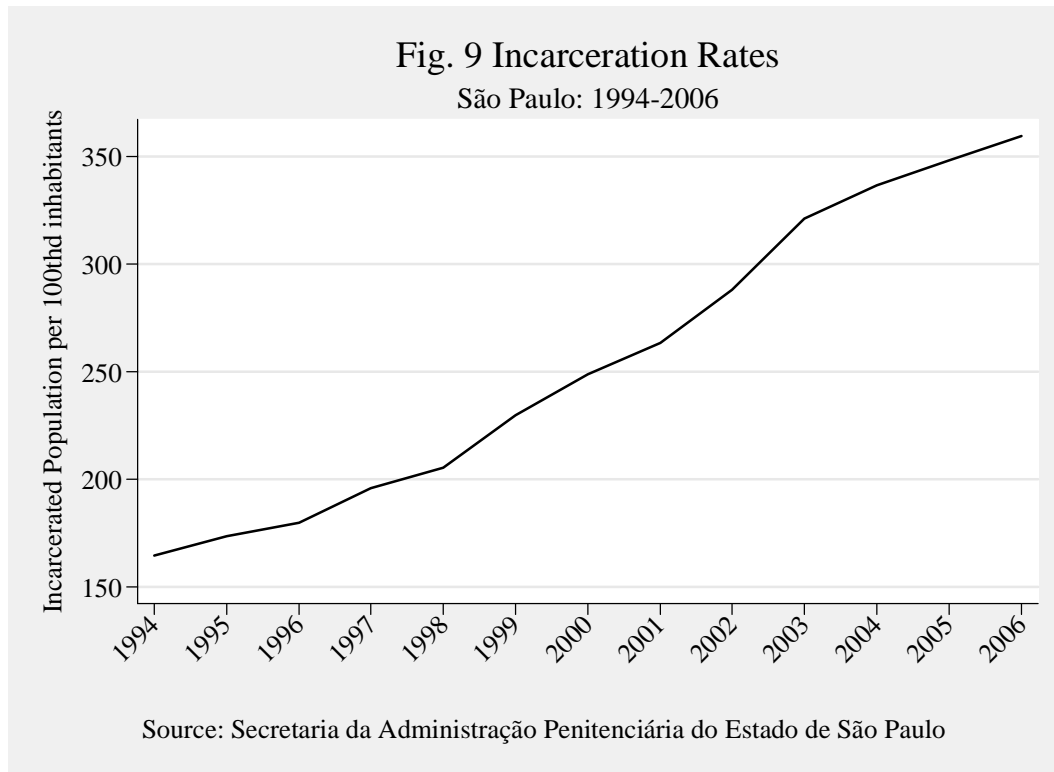
The figure illustrates the difficulty in attributing the dynamics of homicide to incarceration. Incarceration rates rise monotonically, suggesting that, at least for the period of the 1990s, incarceration reacted to crime, and not contrary. Incarceration continues to increase in the 2000s even as crime decline, possibly reflecting an increased toughness in law enforcement. Nevertheless, it is hard to attribute causality. Among other things, incarcerated population increases at a reduced pace in the period 2004-2006, when compared with the 1994-2003 period, again suggesting reverse causality.

4.3 Municipal Level Interventions

Public security is mainly a state attribution in Brazil. Nevertheless, municipalities also reacted to the surge in crime during the 1990s, enacting laws and implementing crime-fighting policies. In this sub-section we describe the most important ones.

A most publicized local intervention was the adoption of mandatory night closing hours for bars and restaurants, popularly known as "Dry Laws". In the SPMA, sixteen out of thirty-nine municipalities adopted such restriction on bars' opening hours. Evidence suggests that dry laws did have causal impact on homicides. Biderman et al (2009) find that dry law caused a 10% decline in homicides. Although this impact is practically relevant, "Dry Laws" cannot rationalize aggregate movements of crime in São Paulo. First, the first city to adopt was Barueri in March of 2001, i.e., almost two years after the peak of homicides. Second, the decline in homicides is much deeper than 10%. Finally, the breadth of the decline is much ampler than a few cities in the SPMA, as figure 1 shows.

Another important local-level policy was the *Disque-Denúncia*, an anonymous hotline for reporting crimes and suspicious activity. *Disque-Denúncia* is a state-level policy that started in October 2000. Eight out of the thirty-nine municipalities passed laws mandating that the *Disque-Denúncia* number should be publicized the number in public places (schools, hospitals, buses, etc). See Kahn and Zanetic (2005). Evidence suggests that adherence to the *Disque-Denúncia* program did have an impact on crime (see Kahn and Zanetic (2005)). Again, this impact is not strong enough, wide enough and implementation was not early enough to explain the aggregate dynamics of crime in the state of São Paulo.[11]

Other important municipal policies were the establishment of municipal police forces and municipal secretaries of public safety. Again, their timing and breadth are not compatible with being a first-order explanation.[12] In summary, municipal interventions contributed to the decline in crime rates but they cannot explain the general aggregate movement in crime in the state of São Paulo.
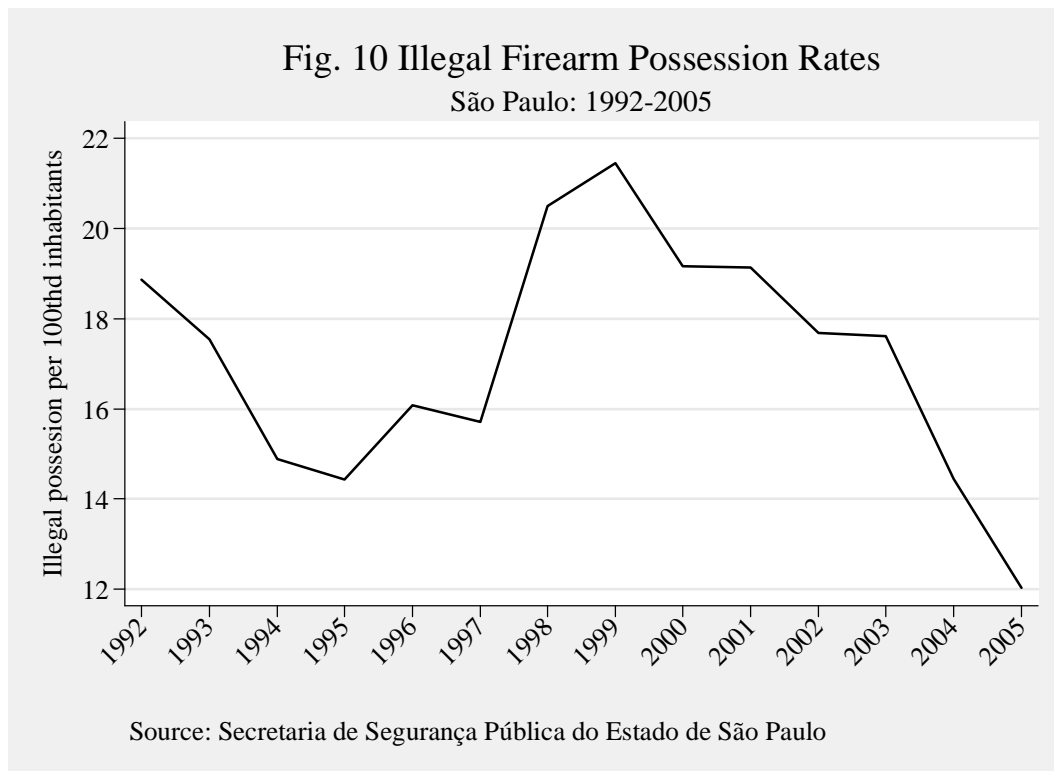
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[11] Kahn and Zanetic (2005) point out the big surge in calls in the Santos Metropolitan Region (the second largest in the state) in 2004, when Santos adhered to the system. Homicides in Santos had been declining for four years at that point.
[12] See Kahn and Zanetic (2005) on the timing of secretaries of public safety and municipal police forces.

4.3 Gun Control

In December 2003, the federal congress passed a federal law that substantially restricted the legal possession of firearms, and substantially increase the penalties for illegal possession (*Lei do Desarmamento*). While it is clear that this legislation cannot explain the timing of the shift in homicides, it does suggest that gun control did increase over the period. Anecdotal evidence suggests that starting in 1997 the state of São Paulo cracked down on the illegal possession of firearms, which leads local analysts to attribute the sharp swings in homicides to gun control (see *The Economist* 2005 and Goertzel and Kahn (2007)).

Figure 10 has the data on rate of illegal firearm possession over the 1992-2005 period (period of data availability).

Fig. 10 Illegal Firearm Possession Rates
São Paulo: 1992-2005

Source: Secretaria de Segurança Pública do Estado de São Paulo

The time-series pattern of illegal firearm possession seemingly matches the pattern of the homicide data. However, a few subtleties obscure causal interpretation. First is the issue of measurement. Reported illegal firearm possession is a combination of

the prevalence of firearms in the population (which one wants to observe) and police enforcement (which one wants to isolate). Consider the increase in illegal possession starting in 1997. This movement is in line with the anecdotal evidence that police cracked down on illegal gun possession (see Goertzel and Kahn (2007)). Thus, the hike in late 1990s less is not due to an increase in firearm prevalence but to a tightening in enforcement. Along these lines, if one is prepared to assume away the problem of measurement and consider that the movement in illegal possession in the late 1990s was in fact an increase in prevalence, then one must also assume it was so in the early 1990s. But then it is hard to reconcile the movements in firearm prevalence and homicides. In summary, it seems that movement in guns prevalence played a role in the reduction of violence in the 2000s but it explains neither the increase in violence in the 1990 nor the reversal in the late 1990s.

5. The Demographic Explanation

This section shows evidence that the age structure is the main determinant of the aggregate movements in homicides in the state of São Paulo. First, we show that young males aged 15 to 24 are not only the main victims of homicides, but also the main perpetrators. Second, we show that the aggregate time-series patterns of population aged 15 to 24 matches perfectly the time-series pattern of homicides: the age-group 15-to-24 increases during the 1990s, reaches a peak in 2000 and the drops. Finally, we use a panel of cities to estimate the elasticity of homicides rates to changes in size of the 15-to-24 year-old population. Elasticities are estimated controlling for city and year fixed-effects. Thus, results account for all time-invariant city heterogeneity and, more importantly, to all aggregate (common to all cities) shocks to homicides and age structure. The only variation left is how the age structure changed differently in different cities. Thus no spurious pure time-series relationship arises.
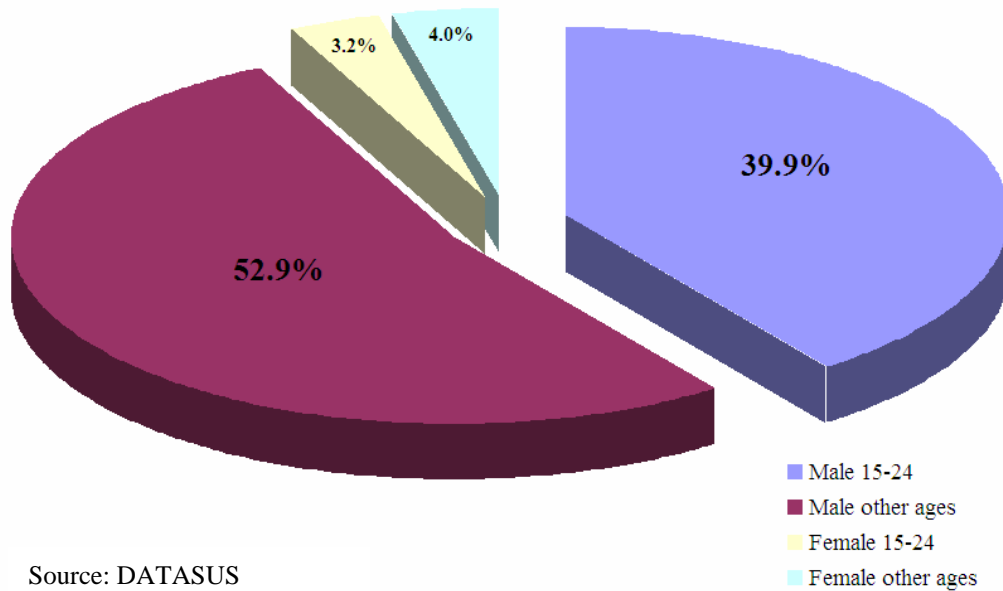
5.1 The Demographic Hypothesis

At the individual level, criminal involvement and age is one of the most robust relationships in all social sciences, dating back to at least Goring [1913]. A very non-exhaustive list of more recent work would include Wilson and Herrnstein [1985], Blumstein [1995] and Cook and Laub [1998].

Despite the individual level evidence, and the pronounced importance of the 15-24 cohort in both perpetrating and being victims of homicides, recent literature is ambiguous as to the importance of changes in age structure to explain aggregate crime. Fox (2000) find that demography explains the major homicide trends from the mid 1960s through the mid 1980s, but account neither for the increase in violence in 1980s nor for the reduction during the 1990s. Holding age-specific murder rates constant, Levitt (1999) finds that changes in age-structure explain less than 10% of the aggregate time-series variation over the 1960-1995 period. Zimiring (2007) examines in depth all the explanations for what he calls "the great American crime decline". He shows that demographic trends were favorable in 1990s. Similarly to Levitt (1999), he also shows that, holding either *ex-ante* or *ex-post* age-specific homicide rates constant, changes in age structure cannot account for the magnitude of the shift in homicides. However, in both cases, the interpretation of the decomposition hinges crucially on the assumption that age-specific homicide rates do not change with the size of the age group. With Brazilian data, I find that the size of the 14-25 age group affects homicide rate for ages 15-24, which invalidate procedures such as Levitt's (1999) (see section 8). For this reason I adopt the strategy of computing elasticities, and use them to predict homicides.

Using hospital data, figure 10 shows the age distribution of homicide victims in the period 1991 through and 2006 in the state of São Paulo. Persons aged 15 to 24 represent almost 40% of homicide victims. The second most victimized category is 25-34 with roughly 30% of victims. If one uses data from the state-level secretary of security, the 15-24 represents a higher proportion of perpetrators of homicides, around 45% in 2003.

Fig. 10 **Distribution of Homicide Victims by Age and Gender over the 1991-2004 period**

Source: DATASUS

In summary, the demographic hypothesis is theoretically plausible for the state of São Paulo. In the sub-sections we test whether it is empirically relevant.

5.2 Time-series patterns

Table 2 shows some descriptive statistics for SPMA and for all other cities with more 100thd inhabitant, for three periods: 1991-1995, 1996-2000, and 2001-2005. Two key variables are depicted: homicide rates and % of male population aged 15-24.

TABLE 2: Means for three different periods

	SPMA†		*OTHER LARGE CITIES‡*	
	Homicide Rate§	**% Male 15-24**	**Homicide Rate§**	**% Male 15-24**
1991-1995	41.79	9.37	15.83	9.36
1996-2000	54.66	9.58	25.54	9.58
2001-2005	45.95	9.18	23.87	9.37

†: Cities in the São Paulo Metropolitan Area
‡: Cities with more than 100thd inhabitants in 2000
§: per 100thd inhabitants
Source: DATASUS and Instituto Brasiliero de Geografia e Economia (IBGE)

Table 2 summarizes the story of the paper. Homicides rates and the percentage of males between 15 and 24 years old move together over time. Suggestively, in large cities outside the SPMA, where the demography varied less, crime also varied less.

To assess how much the demography explains of the time-series pattern of crime we perform two Oxaca-Blinder-type decompositions. The DATASUS data has information on the victims' age, which can be used as proxy for age group specific homicide rates.[13]

Let H_{ta} be the homicide victim rate of age group a in year t. Victims are divided into nine groups, and t = 1991, 1992,...., 2004.[14] Let P_{at} be the proportion of the population that, at year t, is the age group a. The overall homicide rate at time t is approximately[15]:

$$H_t = \sum_a P_{ta} H_{ta}$$

Define H_{ta_τ} as the homicide rate that would prevail in year t if age group specific homicides are kept constant but the demographic distribution changed to that of year τ. In other words:

$$H_{ta_\tau} = \sum_a P_{\tau a} H_{ta}$$

H_{ta_τ} is used a rough prediction of what would the homicide rate be in year τ if the demography changed but the level of homicides of year t were kept constant. Figures 11 and 12 show predicted and actual homicides for the 1984-2004 and 1991-2004 periods, holding homicide victim rates of 1984 and 1991, respectively.

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[13] Levitt [1999] uses incarceration data, which is generated on the offender side, a better but unavailable measure.

[14] Groups are 0-4, 5-14, 15-24, 25-34,35-44,45-54,55-64,65-74 and over 75.

[15] The "actual" homicide is rate is the sum of homicides over the sum of population.

Fig. 11 Predicted versus Actual
Base 100 in 1984
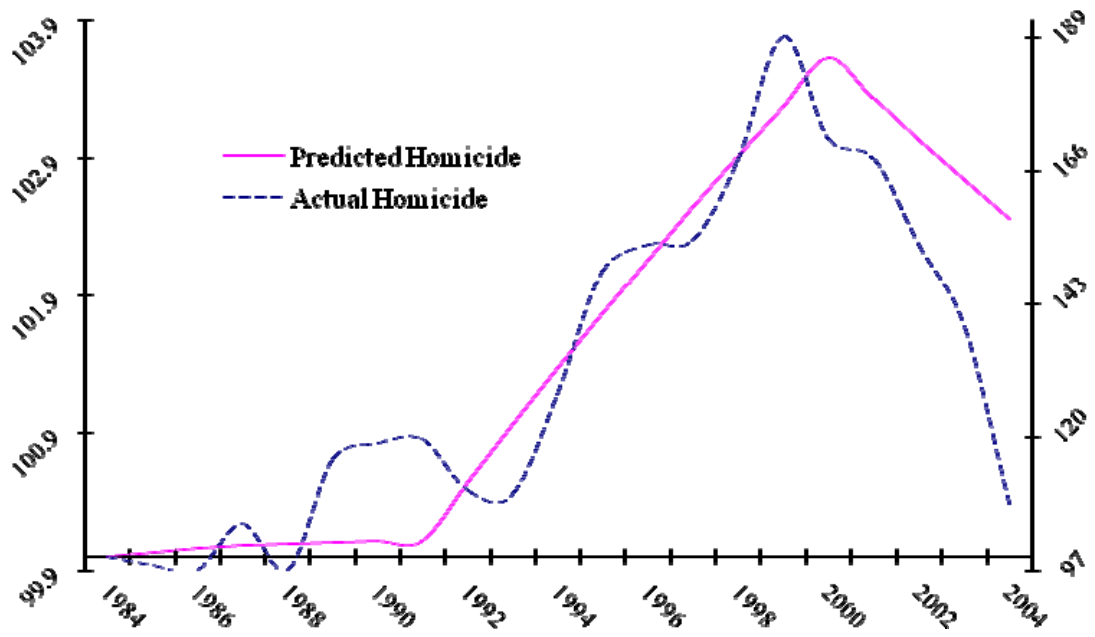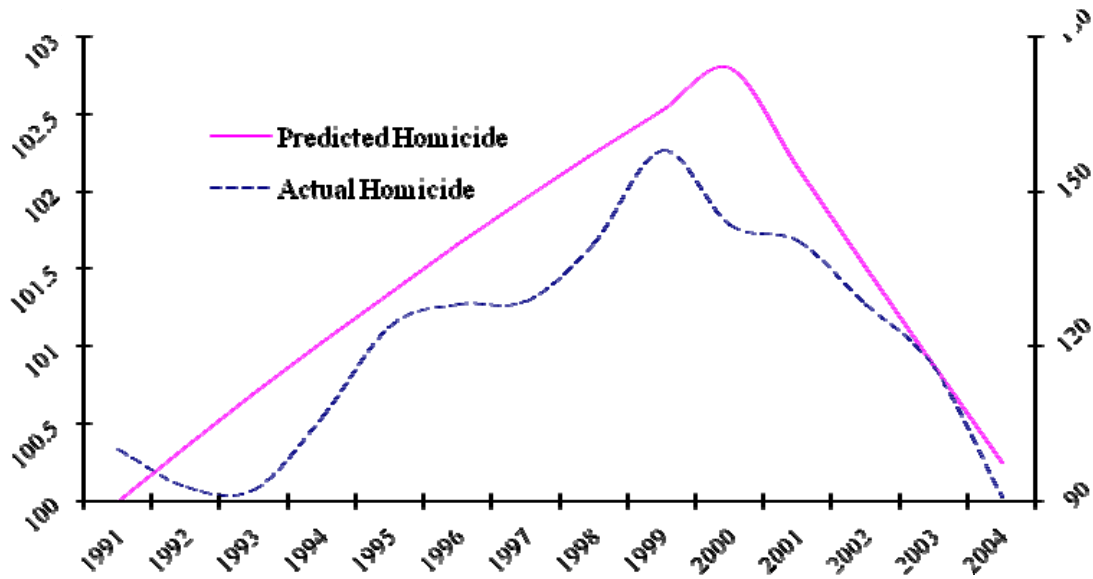
Fig. 12 Predicted versus Actual
Base 100 in 1991

Visual inspection of figures 11 and 12 show two facts. First, there is a remarkable co-movement between the two series. This is true for the whole 1984-2004 period, and for the sub-period 1991-2004. Thus, not only changes in the size of the 15-24 age-group predict homicides *but also changes in the whole age structure of the population.* Second, demographic changes do not pin down the level of homicides, but the decompositions are a qualitative exercise. As Levitt (1999) shows, quantitative interpretation is only warranted when the age-group specific crime rates are not a function of the population in the age-specific groups. Levitt (1999) finds evidence for US data that this assumption is satisfied. With São Paulo data this is not the case. Regressions, whose results we omit, show that age-specific homicides rates are functions of age-specific population. Thus, only the qualitative interpretation of timing of increase and decrease is warranted. As Zimiring (2007) shows, a non-trivial difference exists if we use *ex-ante* or *ex-post* age-specific homicide rates. If *ex-post* rates were used, predicted homicides in 1999 would be 30% higher than in 1991. This is still short of the 78% increase, but it is much closer. In

any event, when specific homicide rates are a function of population then qualitative movements are more informative than quantitative ones.

5.2 Panel Evidence

Ultimately demography and crime are not randomly determined but are choices of the agents. Consequently, the relationship between demography and homicides may suffer from the usual problems: of reverse causality and omission of common determinants. Additionally, using time series variation alone one cannot dismiss the possibility that the relation arising in figures 11 and 12, and table 2 are a product of a sheer coincidence (although demography and homicides seem related above and beyond the inclusion of a high-order polynomial of time).

Reverse causation seems highly improbable, at least as a first order phenomenon empirically. It is true that homicide victims are concentrated in the male age bracket 15-24. There are, however, too few murders to make a significant difference. For an illustration, at its 1999 peak, the city of São Paulo had 2418 homicides whose victims were 15-to-24-year-old males. Although the number is certainly very high, it amounts to no more than 0.25% of the 969,241 young males living in São Paulo that year. Furthermore, reverse causation, in this case, would bias the estimated relationship between demographics and crime towards zero

Demography has two pillars. One is fertility and mortality, which largely produced by decision made several years - if no decades - before. Second is migration, a shorter-term decision. Similarly, crime is a decision made in the present. From the first channel (fertility), there is little chance that demography and crime have a common cause. Migration is more challenging for the estimation strategy, and it is further discussed below.

In this subsection we estimate how demography impacts violent crime using, along with variation over time, how demography evolved in different large cities in the state of São Paulo. Cross-city variation allows us to evaluate the "coincidence" explanation. Let i be a city and t be a year. The estimated model is:

$$\log(Homicide)_{it} = \beta_0 + \beta_1 \log(Male1524)_{it} + Controls_{it} +$$

$$\sum_{t=1}^{T} \tau_t TIME_t + \sum_{i=1}^{I} \iota_i CITY_i + \varepsilon_{it} \tag{1}$$

Homicides are rates per 100thd inhabitants, *Male*1524 is the percentage of 15-24 year-old males. $TIME_t$ is a full set of year dummies, and $CITY_i$ is a full set of city dummies. *Controls*, in some specifications, will include the log of population and the log of the high-school dropout rate. These two controls are quite important for our purposes. First, population will capture migration movements, the component of demography that is a product of current choices of agents. Second, it may be easier to maintain youngsters at school if there fewer of them.

With a panel structure, one can discard *all* pure time-series variation (and all pure cross-city variation), leaving only how demography changed *differently in different cities* as a source of variation to estimate its impact on homicides. Several more layers of coincidence are now necessary to produce the results spuriously. Second, we can account for all time-invariant heterogeneity among cities, which helps identifying the effect of demography. The different panels in figure 13 illustrate graphically the type of variation explored when estimating equation (1). The proportion of 15-24 year-old males and homicide rates are depicted for five large cities statewide.[16]

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[16] We depict no more than five cities for the sake of conciseness. Several other cities would confirm the pattern.

Figure 13: Homicides and % aged 15-24 in different cities

Itapecirica

São José dos Campos

Embu

São Paulo

Suzano
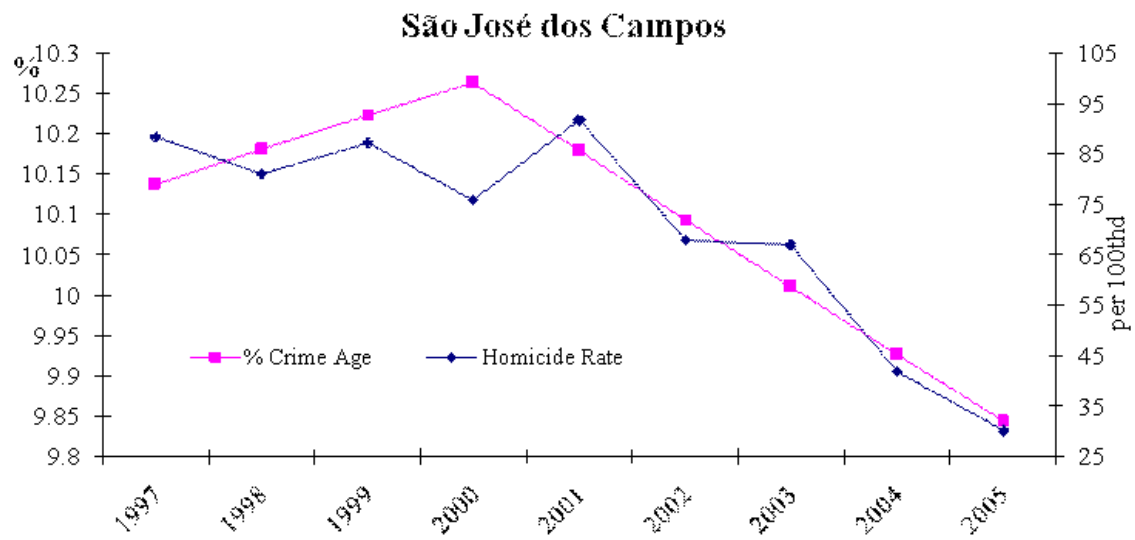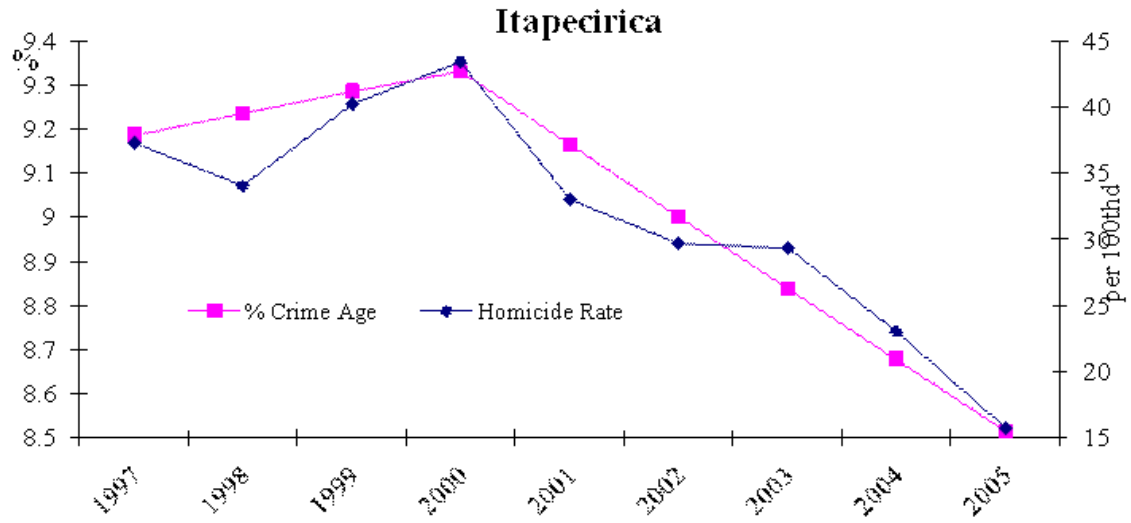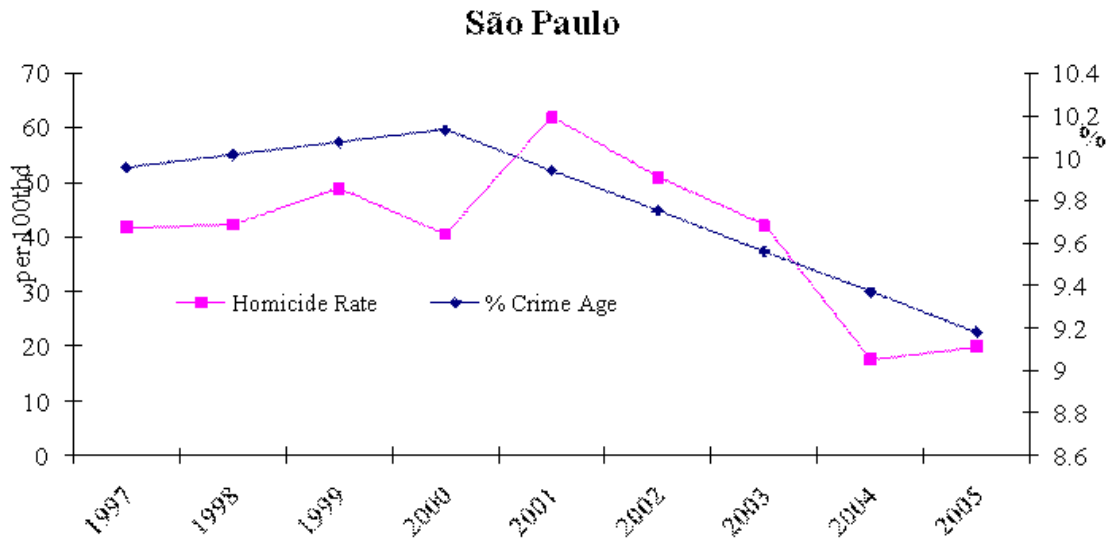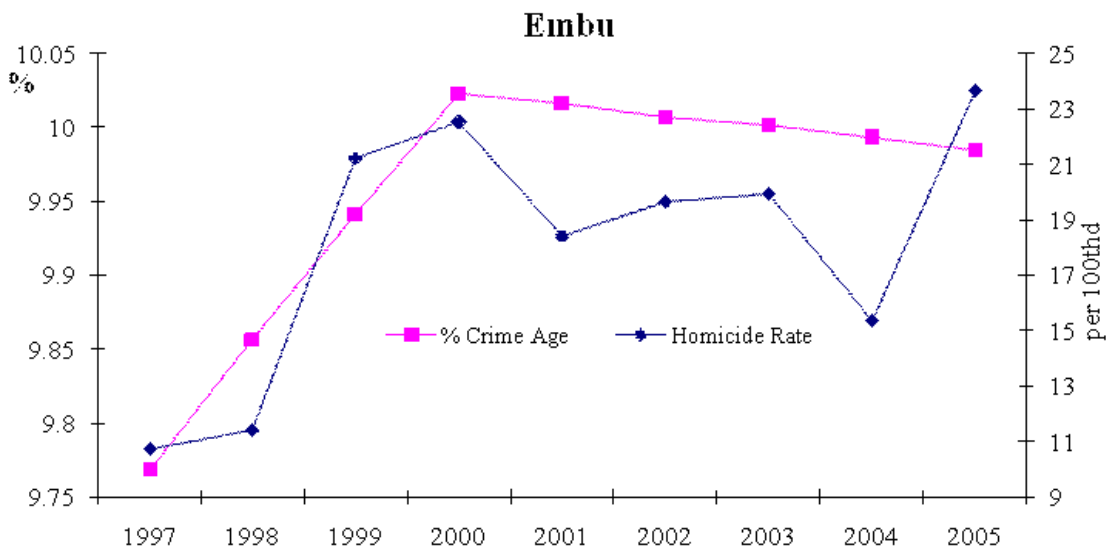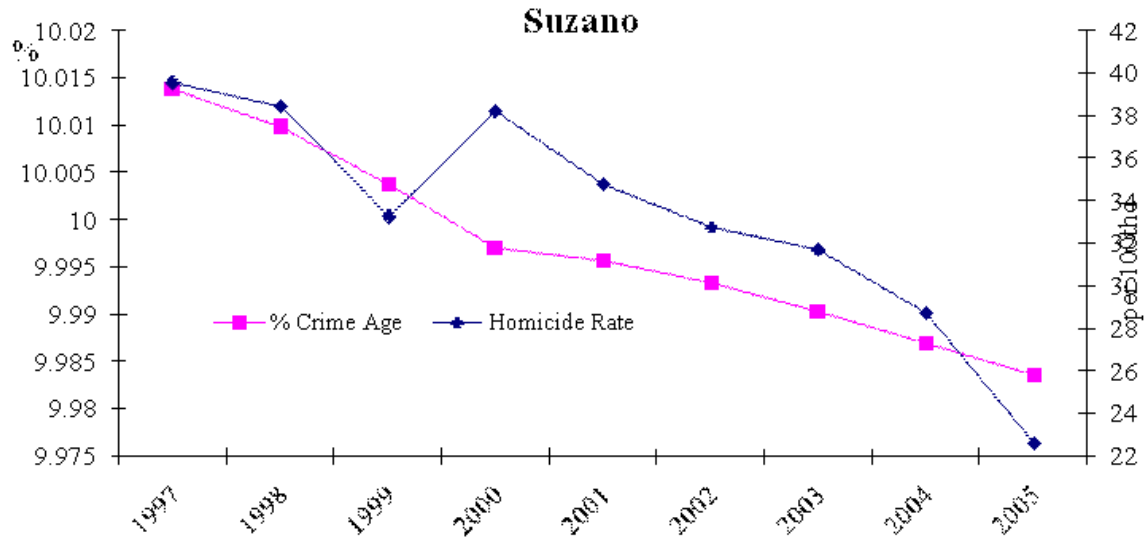
São Paulo, São José dos Campos and Itapecirica follow the typical pattern: proportion of 15-24 year-old males increased until 2000 and fell thereafter, with homicides following the same pattern. However, where the proportion of 15-24 year-old males increased less pronouncedly, and fell less pronouncedly (São Paulo), homicides also went up smoothly and fell relatively smoothly. In other cities, such as São José and Itapecirica, the proportion of 15-24 year-old males increased smoothly, but then drop steeply, homicides also increase smoothly and then dropped pronouncedly. Finally, consider Suzano and Embu. In the former, the proportion of 15-24 year-old males fell throughout the 1997-2005 period, and homicides followed the same pattern. On the other, in Embu the proportion of 15-24 year-old males increased sharply until 2000, and so did homicides; from 2000 onwards, the proportion of 15-24 year-old males fell very subtly, and so did homicides.

Table 3 presents several models estimated using only data from the São Paulo Metropolitan Area (SPMA), in which case there is data starting in 1991.

TABLE 3 Homicide Regression, SMPA 1991-2005
Dependent Variable: Log of Homicide Rate per 100thd inhabitants

	$(1)^A$	$(2)^A$	$(3)^B$	$(4)^B$	$(5)^B$	$(6)^B$	$(7)^B$	$(8)^B$
Log(Crime Age)	3.92 (0.43)***		4.95 (0.59)***		2.02 (0.63)***		1.71 (0.70)**	
Log(Crime Age)$t-1$		4.18 (0.46)***		5.48 (0.75)***		2.65 (0.77)***		2.37 (0.83)***
Log(Population)							0.19 (0.28)	0.18 (0.31)
Log(Dropout Rate)^C							0.04 (0.06)	0.03 (0.06)
Year Dummies?	No	No	No	No	Yes	Yes	Yes	Yes
# Obs	515	482			515	482	514	481
R^2	0.12	0.13	0.70	0.70	0.76	0.77	0.76	0.77

All standard errors are White-Huber heteroskedastic corrected, unless otherwise noted
***: significant at the 1% level
**: significant at the 5% level
*: significant at the 10% level
A: OLS Regression
B: Fixed-Effects Regression
C: High-school dropout rate, moving average over the second and third lags
Source: Secretaria de Segurança Pública de São Paulo (SSP-SP) and Instituto Brasiliero de Geografia e Economia (IBGE)

Column (1) presents the simplest possible model, without city or year dummies and with no controls included. A 1% increase in the percentage of 15-24 year-old males is associated with 3.92% increase in homicides. To have a sense o practical importance, over the 1996-2000, there were 9.58% of young males in the SPMA, and 9.18% in the 2001-2005 period (see table 2), which represents a 4.2% difference. Therefore, the coefficient implies that 16.37% of the reduction in homicides, which actually fell some 16% over the period.[17] Since it is not clear whether current or (recent) past demography matters, homicides are regressed on the lag of *Male*1524 (column (2)). Results are even stronger.

Interestingly, when city-fixed effects are accounted for, the impact of demography is *stronger*, for both contemporaneous and the lag (4.95% and 5.48%). As expected, including year dummies dampens results, and so does including the two controls. However, we can always reject the null hypothesis of that demography does not cause homicides at reasonable significant levels. The lowest possible estimates arise when the two controls, population and high-school drop-out rates. Neither population nor drop-out rates seem to belong to the equation, but the percentage of 15-24 year-old males do. At

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[17] This is an extrapolation of a local interpretation of the log-in-log regression.

the lowest estimate, changes in the *Male*1524 imply a reduction of 7.14% in homicides from the second half of the 1990s and the first half of the 2000s. Finally, in column (9), the most complete model is estimated using a moving average of *MALE*1524. Results, as expected, are between those in columns (7) and (8). In table 4, again using data from the SPMA, several econometric robustness checks are performed. For the sake of conciseness all models are estimated with the moving average of column (9).

TABLE 4 Homicide Regression, SMPA 1991–2005
Dependent Variable: Log of Homicide Rate per 100thd inhabitants

	(1)[C]	(2)[C]	(2)[D]	(3)[D]	(5)[E]	(6)[E]	(7)[F]	(8)[F]
Average Log(Crime Age)[A]	1.87	1.77	2.58	2.40	2.80	2.81	3.28	5.13
	(0.57)***	(0.67)***	(0.97)***	(1.10)**	(0.98)***	(1.07)***	(0.91)***	(1.07)***
Log(population)		0.01		0.01		0.04		-1.62
		(0.21)		(0.40)		(0.47)		(0.59)***
Log(Dropout Rate)[B]		0.07		0.40		0.07		0.40
		(0.05)		(0.45)		(0.05)		(0.49)
ΔLog(Homicide Rate)$t - 1$					0.28	0.28		
					(0.05)***	(0.05)***		
Year Dummies?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# Obs	481	481	482	481	436	436	317	316
R^2	0.79	0.79	0.76	0.76			0.83	0.83

All regressions account for city fixed effects. All standard errors are White-Huber heteroskedastic corrected, unless otherwise noted
***: significant at the 1% level
**: significant at the 5% level
*: significant at the 10% level
A: Moving average over current and first lag
B: High-school dropout rate, moving average over the second and third lags
C: Weighted Least Squares, Weight = Population½
D: GLS Regression, model for the error term: AR(1)
E: Arellano-Bond GMM Regression, all varibles in first-differences
F: Year ? 1997
Source: Secretaria de Segurança Pública de São Paulo (SSP-SP) and Instituto Brasileiro de Geografia e Economia (IBGE)

Four pairs of regressions are presented, including and not including the controls. All regressions account for city and year fixed effects. The first is a pair of Weighted Least Square regressions, in which the variance is modeled as a decreasing function of population. There are cities of wildly different sizes in the SPMA, and homicides are a relatively rare occurrence, observations from small cities are very noisy. Results are in line with those in column (9) table III. While in columns (1) and (2) the variance is modeled, in columns (3) and (4) the autocorrelation in modeled as an AR(1) process. Results are stronger.

In dynamic models, if the first lag belongs to the equation, and errors are auto-correlated (which columns (3) and (4) suggest is the case), the first lag is endogenous, and all coefficients are biased. To account for this possibility, we estimate the model by GMM using lags of the regressors as instruments (see Arellano and Bond [1991] for details). Even after including the first lag of homicide, results are once more stronger (columns (7) and (8)).[18]

Finally, the model is estimated with the sample restricted to 1997 onwards, for two reasons. First, by shortening the sample on the time dimension, one reduces the odds that time-varying unobserved heterogeneity across cities is driving results. Second, and more importantly, for 1997 onwards data are available for cities outside the SPMA. Results are significantly stronger than those with the whole 1991-2005 sample. In table 5, some of the models presented in tables 3 and 4 are replicated for a sample of all cities with more than 100,000 inhabitants.[19]

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[18] The model is estimated in first-difference. After estimating the model by GMM, we tested for first and second order autocorrelation on the error term. This is important because if *second* order autocorrelation is still present, coefficients could be biased if the second lag of homicides belongs to the equation. While first order autocorrelation is indeed present, after including the first lag of homicides second order correlation is not present.

[19] We do not present all models for the sake of brevity. All other results are in line with those presented.

TABLE V: Homicide Regression, Large Cities 1997-2005
Dependent Variable: Log of Homicide Rate per 100thd inhabitants

	(1)[A]	(2)[B]	(3)[B]	(4)[B]	(5)[B]	(6)[BC]	(7)[BD]	(8)[BE]	(9)[BE]	(10)[BE]
Log(Crime Age)	6.06	6.32	4.67	6.37		5.91	6.03	5.80	3.12	
	(0.50)***	(0.58)***	(1.01)***	(1.07)***		(0.87)***	(1.24)***	(1.54)***	(1.83)*	
Average Log(Crime Age)					7.70					4.35
					(1.22)***					(1.77)**
Log(population)				-2.09	-2.97	-1.71	-1.38	-2.96	-2.99	-3.20
				(0.59)***	(0.70)***	(0.51)***	(0.68)***	(0.82)***	(1.10)***	(1.05)***
Log(Dropout Rate)				0.06	0.09	0.06	0.07	0.10	0.14	0.15
				(0.06)	(0.06)	(0.06)	(0.05)	(0.07)	(0.07)**	(0.07)**
ΔLog(Homicide Rate)t - 1								0.43	0.48	0.46
								(0.08)***	(0.09)***	(0.08)***
ΔLog(Homicide Rate)t - 2									0.37	0.36
									(0.07)***	(0.07)***
Year Dummies?	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# Obs	585	585	585	535	520	436	585	455	390	390
R^2	0.17	0.85	0.86	0.87	0.87	0.38	0.87			

All regressions account for city fixed effects. All standard errors are White-Huber heteroskedastic corrected, unless otherwise noted. Average Log(Crime Age) and Drop-outs as defined in tables III and IV.
*** : significant at the 1% level
** : significant at the 5% level
* : significant at the 10% level
A: OLS
D. City-fixed effects included
C: Weighted Least Squares, Weight = Population½
D: GLS Regression, model for the error term: AR(1)
E: Arellano-Bond GMM Regression, all variables in first-differences
Source: Secretaria de Segurança Pública de São Paulo (SSP-SP) and Instituto Brasiliero de Geografia e Economia (IBGE)

Three important messages arise from the table 5. First, when only the 1997-2005 period is considered results are stronger than with the whole 1991-2005 period. The inclusion of large cities outside the SPMA does not change results in any significant way. We interpret these results as suggesting two facts. First, the phenomenon is wider than the SPMA. Second, with a shorter time length it is less likely that demography captures time-varying heterogeneity. Finally, confirm previous estimates, population seem to reduce homicides, and some models now suggest that more high-school drop-out rates increase homicide as one should expect. The coefficient on population is puzzling in the light of the previous literature on social interaction that would predict crime rates are higher in larger cities (Glaeser, Sacerdote and Scheinkman [1996]). Our results suggest that, perhaps, economically dynamic and safer cities receive an influx of population. Since young males are more prone to moving, unobserved migration movements (imperfectly captured by population) would work towards biasing the impact of young males on homicides *towards zero*.

6. Conclusion and Discussion

Using data from São Paulo, we recover very large impact of age structure on homicides. Using the average panel elasticities estimated in tables 3 through 5 (3.4), we predict *aggregate* homicides using only changes in the *aggregate* proportion of the 15-to-24 year population. Demography predicts a 22% increase in homicides between 1991 and 2000, and a return to the 1991 level in 2004. This matches well the actual movement in homicides.

Aggregate movements in crime in São Paulo and Brazil resemble the case of New York and the rest of the US ten years earlier. A strong common component across cities drove trends crime in the US (see Zimiring (2007)). However, in New York, a harbinger, the movements were more pronounced, especially the decline. Analogously, São Paulo anticipated the rest of the country. Yet another similarity, the decline was particularly pronounced in São Paulo, suggesting that the policy reactions outlined in section 3 did have an impact. However, only demography explains the decline in 2000s, the timing of reversal *and* the surge in the 1990s. This, along with the common component character of the crime trends, shows that demography is the key element driving movements in homicide in São Paulo over the last two decades.

Our results are seemingly in contraction to Naritomi and Soares (this volume), which find only a small role for demography in explaining why crime is high in Latin America. Two facts reconcile the results. First, Naritomi and Soares use age-crime elasticities available in the literature, which perhaps needs revisiting. Second, Naritomi and Soares measure quite a different object: the contribution of different determinants using mainly cross-country differences. We measure the impact of a large shift in one contributing factor over time. Nothing guarantees that the impacts are similar. For example, country *A* may have 1% more young males than *B*, but many other factors may contribute more to explain differences in crime rates. However, if one changes the amount of young males sharply in one country, the impact of age structure may be much stronger, conditional on other determinants being fairly constant. Thus, our results should not be judged by the yardstick of cross-section estimates (Naritomi and Soares's object)

but by the yardstick of identification: is it credible that other things are fairly constant in our data? We claim that it is, especially when panel data is used.

The results in this paper are important *per se* for criminology science. While there is undisputable evidence that offenders are mostly males between 15 and 24 years old), whether age structure has an aggregate impact is not clear. Levitt [1999], for example, finds a limited role for demography. Our result can reconcile these two seemingly opposing pieces of evidence. Although age structure must mechanically contribute to crime rates, whether it makes an aggregate difference will probably depend on law enforcement, the efficacy of the judicial system, institutional development, educational and labor opportunity for young males, etc. Perhaps, in the state of São Paulo, differently from the US, the environment was ripe for demography to "flourish" as a cause of homicides.

The results are also important in terms of policy. While it is hard to influence demography in the short-run, sub-optimal policy over-reaction can be avoided if demography is the driving factor.

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