

The Entry of Colombian Heroin into the US Market: The Relationship between Competition, Price, and Purity

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Abstract

There have been large structural changes in the US heroin market over the past 20 years. Colombian heroin entered the market in the mid-1990s, followed by a large fall in the price per pure gram and the exit of Asian heroin. By the 2000s, Colombian heroin had become a monopoly on the east coast and Mexican heroin a monopoly on the west coast with competition between the two in the middle. We estimate the relationship between these changes in competitive market structure on retail-level heroin price and purity. We find that the entry of Colombian heroin is associated with less competition and a lower price per pure gram of heroin at the national level. However, there is wide variation in changes in market concentration across the US. Controlling for the national fall in the heroin price, more competition in a region or city is associated with a lower price per pure gram.

Keywords: Heroin Price, Heroin Purity, Competition, US, Illicit Drug Markets

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1 Introduction

We examine the effect of the entry of Colombian heroin on the US heroin market. There are four major supplier regions for the US: Mexico, South America (mostly Colombia), Southeast Asia (mostly Burma), and Southwest Asia (mostly Afghanistan). There have been large changes in the availability of heroin from these regions over time. In particular, in the 1990s there was a dramatic decline in heroin supplied from Asia, while South American heroin increased substantially. Furthermore, as shown by Ciccarone et al. (2009), the US supply of heroin is divided geographically with Mexican heroin currently having a monopoly in the west, South American heroin having a monopoly in the east, and competition in the middle.

The competition we measure is that between rival substitute products rather than rival businesses. That is, we want to know what happens when Pepsi is introduced at a supermarket that already offers Coke rather than the rivalry between two competing supermarkets or two competing distributors of Coke and Pepsi. In our case, we focus on the entry of Colombian heroin. It is likely that competition between drug dealers and along the supply chain has a role to play in the effect of the entry of Colombian heroin on the US market. Although this would be useful to understand, we are only able to observe changes in the place of origin of heroin, not the dynamics of the many agents in the heroin market.

We seek to understand the effects of the changes in market structure after the entry of Colombian heroin. In standard economic theory, the more competition there is, the better it is for consumers. The fact that heroin is supplied illegally and is an addictive good makes the theoretical analysis more complex. The theoretical work on addictive goods markets has no general predictions, in that some models predict that increased competition may raise the price while others predict it will lower the price (Driskill and McCafferty, 2001; Richards et al., 2007; Showalter, 1999). On the one hand, competitive pressure may bring prices down. On the other hand, if competition is in the form of violence, then more competition may increase both suppliers' costs, raising the market price (there could be a kind of natural monopoly in heroin). In addition, given that heroin is an addictive good, a monopoly may want to sell below current

market price, knowing it can take full advantage of increased demand in the future. Thus, assuming policy goals are to both reduce heroin use and lower negative externalities from the heroin market, such as crime and disease, it is by no means obvious whether competition is preferable to monopoly. We contribute to the literature on addiction and market competition by providing the first estimates of the relationship between market competition and heroin price and purity.

2 Overview of the US Heroin Market

Figure 1 shows the proportion of heroin samples from each of the major heroin supplying regions. In the early 1990s, Asian heroin represented more than half of the market. By the mid-1990s, South American (i.e. Colombian) heroin went from zero market share to overtaking Mexico as the dominant supplier of heroin in the US. At the same time, the supply of Asian heroin fell to almost nothing.

The United Nations Office on Drugs and Crime (UNODC) provides yearly estimates of opium production by country of origin. Figure 2 shows the estimated potential production for Southwest Asian and Southeast Asian heroin, while Figure 3 shows the estimated production for Mexico and Colombia. Given that opium production is illegal, these should be taken as rough estimates of opium supply. The UNODC generally assumes that 10 units of opium can be converted into 1 unit of heroin, although the exact amount of opium that is converted into heroin is unknown.

Southeast Asian opium production has been declining since the mid-1990s, which coincides with the fall in heroin observations from Southeast Asia in the US market. Laos, Vietnam, and Thailand all had dramatic declines in opium production, however Burma has consistently produced an order of magnitude larger amount of opium than these other countries combined. Although economic development may have led to a reduction in opium production in Laos, Vietnam, and Thailand, the large-scale decline in Southeast Asian opium was likely due to several Burmese states banning opium production between 1997 and 2005 (Paoli et al., 2009).

The decline in supply from Southeast Asia may be able to explain the dramatic decline in Southeast Asian heroin in the US. However, there has been a rise in opium production in Southwest Asia, with the exception of the short-term eradication campaign by the Taliban in Afghanistan in 2000-2001 (Gibson et al., 2005; Ciccarone, 2005). The fall in the US market share since the early 1990s may be due to an inability to compete with Colombian heroin, which likely has significantly lower transportation costs. The drop in Southwest Asian heroin's US market share may also be due to Afghanistan filling the void in Europe and Asia left by the large decline in Southeast Asian heroin. Paoli et al. (2009), Ciccarone (2009), and Ciccarone (2012) discuss the existence of segmented markets, where heroin is supplied to particular places by particular suppliers through a limited number of trafficking routes. Once Asian heroin left the US market and their trafficking routes were reduced, there could be substantial barriers to re-entry.

The potential opium supply from Mexico remained steady until the 2000s, when it began to rise. Colombia's potential opium supply increased rapidly in the mid-1990s, before declining in the 2000s. Although the rapid increase in opium production in Colombia can explain Colombian heroin's take-over of nearly half the US market, the UNODC's estimate of a substantial rise in the Mexican opium supply does not explain why the Mexican market share has remained steady and generally below Colombia's since the mid-1990s. One possibility is that the UNODC overestimated Mexican production and underestimated Colombian production in the 2000s. Another possibility is that the recent Mexican Drug War has limited the amount of heroin that enters the US from Mexico.

On the supply side, it appears that there has been a general increase in opium production. The combined estimated opium production in Colombia and Mexico has more than doubled since the early 1990s. As we will show, there was a substantial decline in the price per pure gram of heroin over the 1990s. However, consumer demand is an equally important factor in determining price. Figure 4 shows the proportion of high school seniors that report using heroin in the past year. Reported heroin use more than doubled in the mid-1990s, and then slowly declined in the 2000s. Brady et al. (2008) estimate the prevalence of injection drug

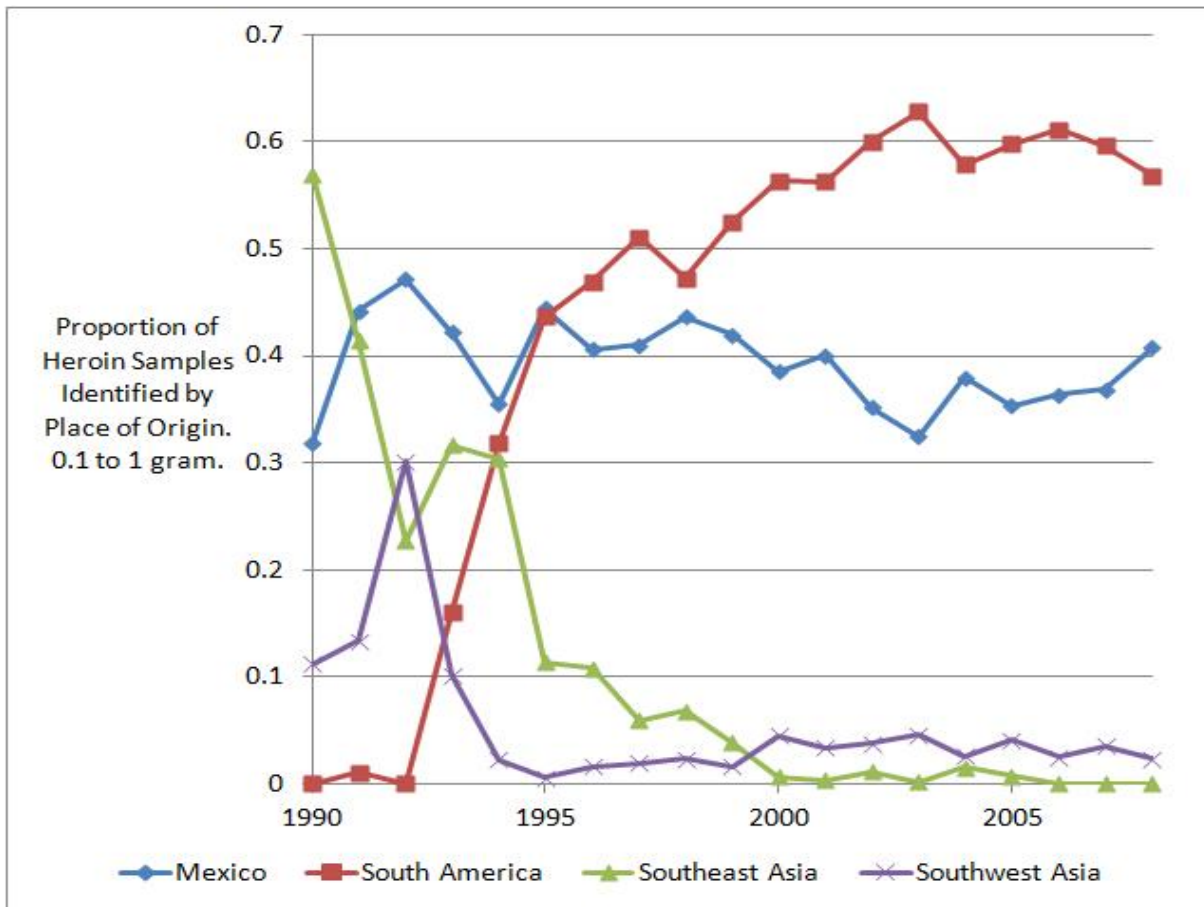


Figure 1: Change in heroin supplier regions from 1990-2008. Data Source: STRIDE Database.

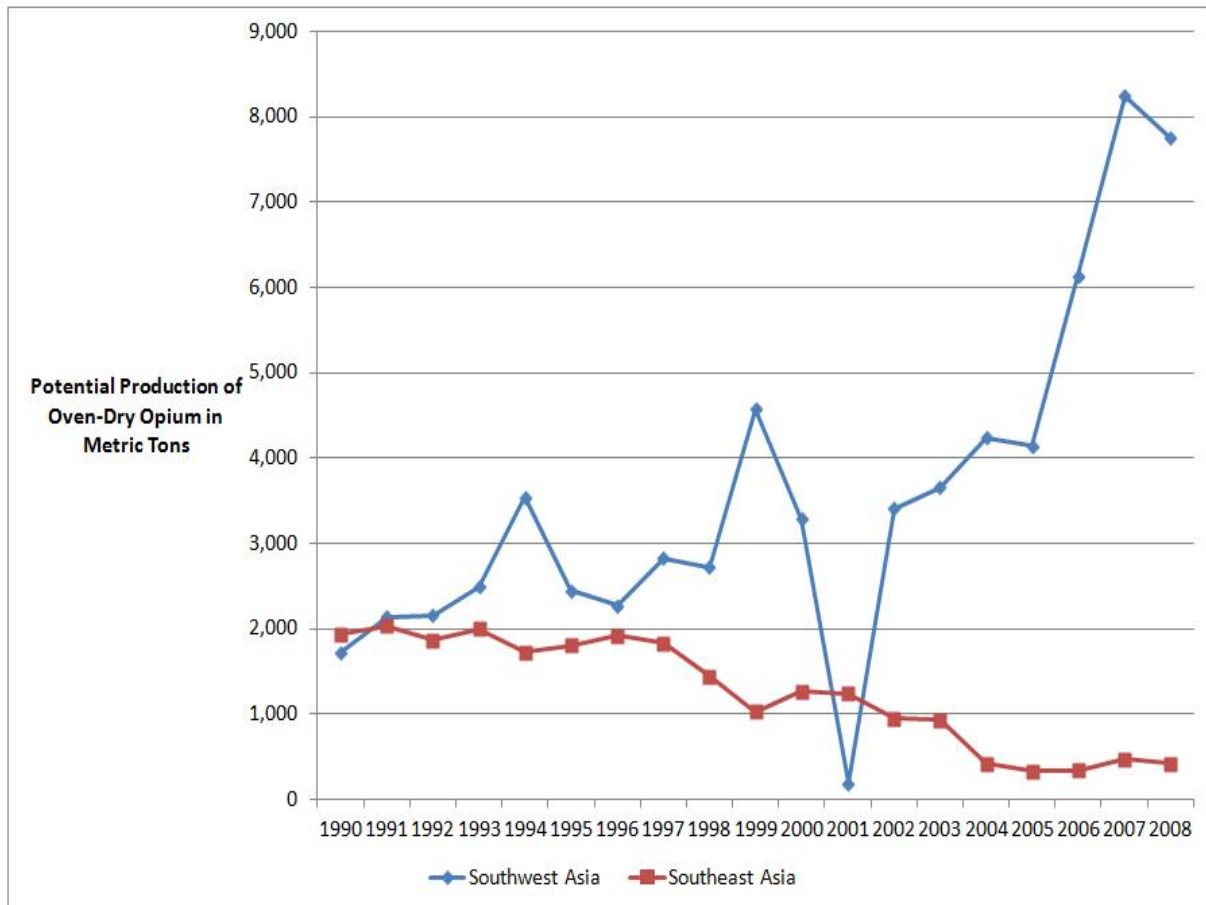


Figure 2: Potential Asian opium production 1990-2008. Data Source: UNODC (2003) Table 2.1.1 and UNODC (2011) Table 13.

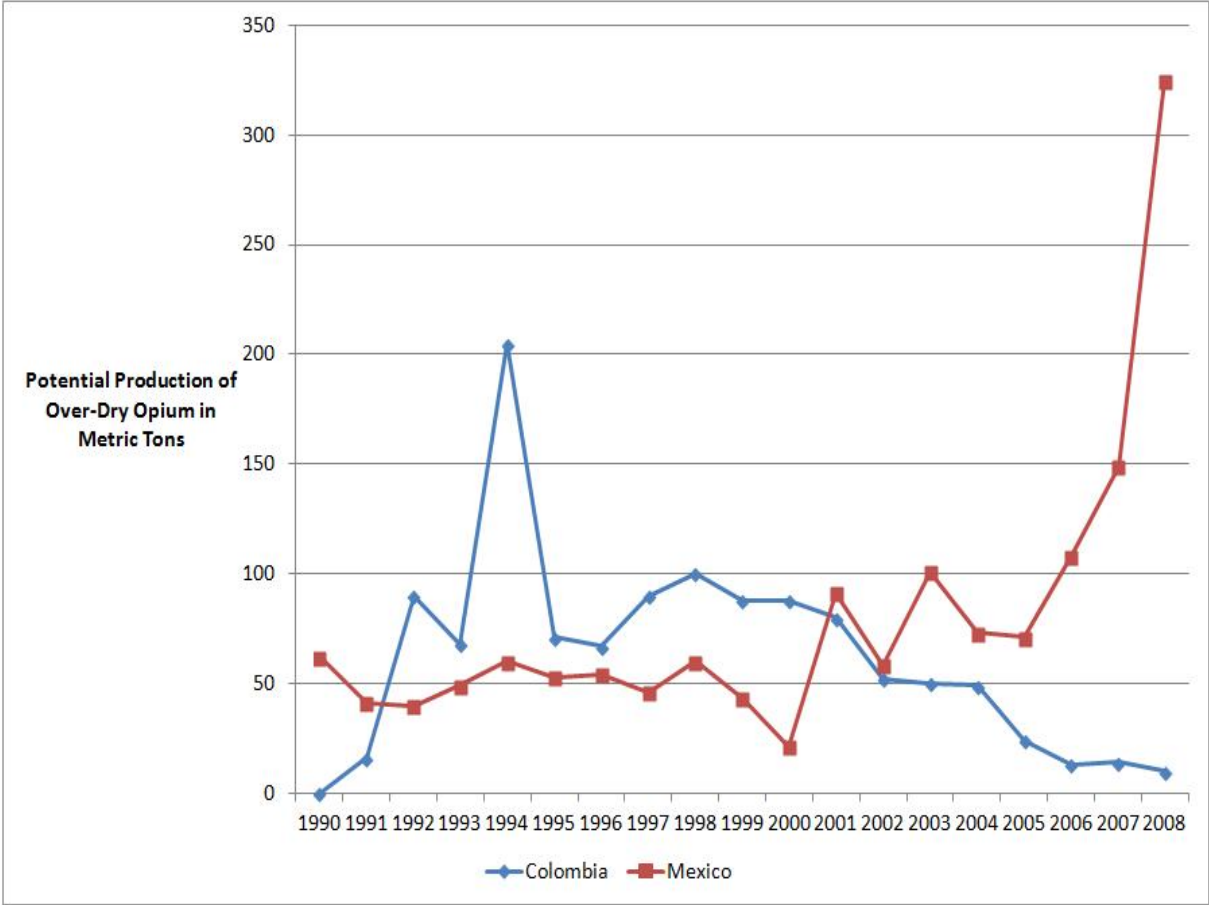


Figure 3: Potential Mexican and Colombian opium production 1990-2008. Data Source: UNODC (2003) Table 2.1.1 and UNODC (2011) Table 13.

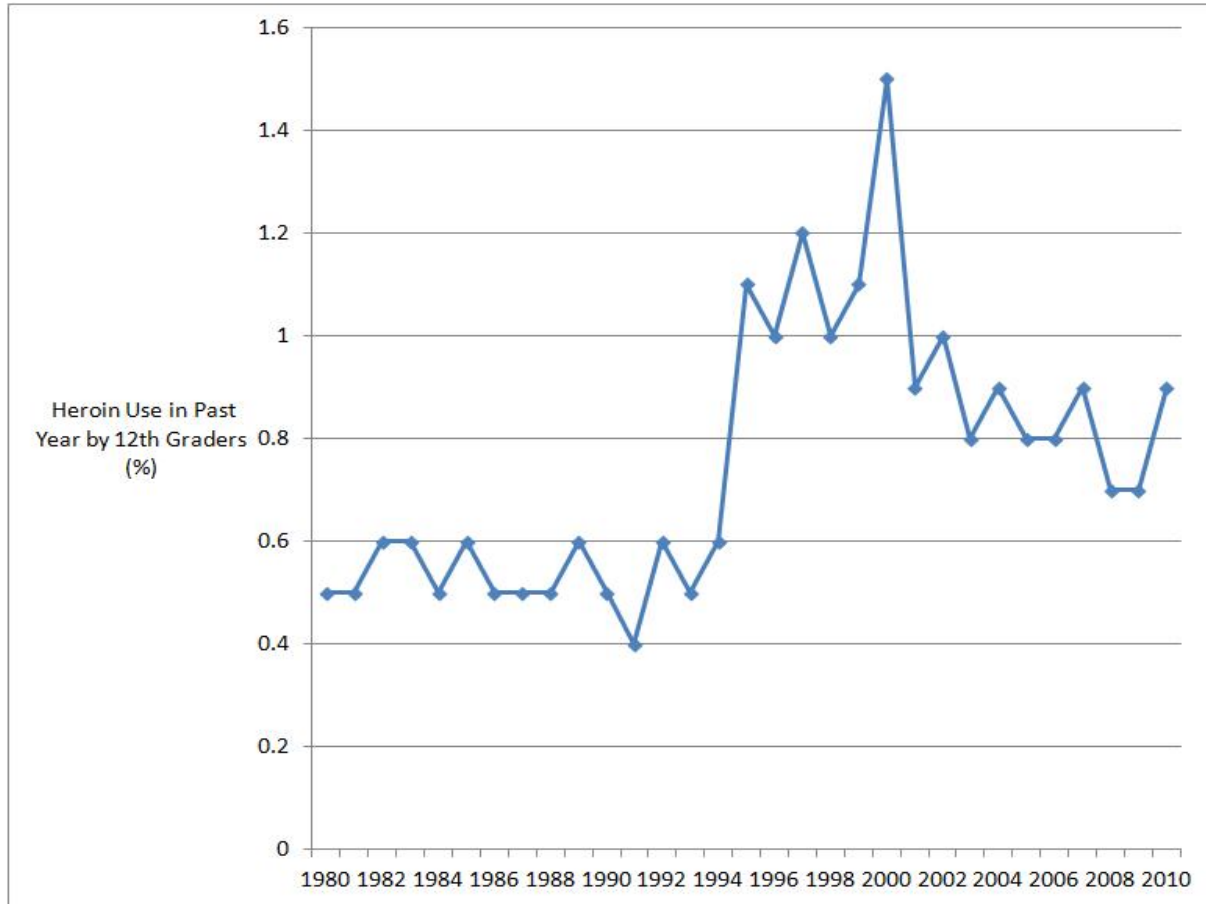


Figure 4: Proportion of high school seniors reporting heroin use in the past year. Data Source: Johnston et al. (2011), Table 5-2, p. 200.

use in the overall US population and find a similar pattern. Thus, demand increased just as Colombia entered the American market. That heroin prices fell substantially over the 1990s, indicates that the fall in prices was due to an increase in heroin supply rather than a decrease in demand. The low prices of the late 1990s no doubt contributed to the concurrent rise in heroin use.

3 Data

Our analysis uses the DEA's System to Retrieve Information from Drug Evidence (STRIDE) database.¹ STRIDE includes information from drug seizures and arrests. These observations include the amount and purity, but generally not the price or country of origin. In addition, there is information from law enforcement purchases of heroin, which include price as well as amount and purity. STRIDE includes additional information from the DEA's Domestic Monitor Program (DMP), in which agents purchase illegal drugs and record the price and test those drugs for purity and country of origin. The DMP data is collected to monitor the retail level price and purity of heroin. There is no connection between this data and criminal investigations as in the rest of the STRIDE data. STRIDE also includes data from the Heroin Signature Program (HSP), which tests a sample of heroin seized at borders and from arrests for the heroin's country of origin. All observations include heroin purity. The 37 percent of observations with a recorded price are used to estimate the price per expected pure gram. The 32 percent of observations with a recorded country of origin (from the DMP and HSP) are used to estimate market competition.

There is disagreement about whether the STRIDE data can be used reliably. Horowitz (2001) argues that the STRIDE data has limited use because the data does not represent a random sample. In particular, Horowitz (2001) finds that the drug observations have different means and time trends within cities depending on the method of acquisition. However, Arkes et al. (2008) further divides the sample by distribution level (low amounts at the retail level; high amounts at the wholesale level) and find that trends are consistent within cities in these subgroups. They argue that although the mean estimate in a given city and time period may not reflect the market's actual price, the city-specific time trends in price and purity can reasonably be estimated with the STRIDE data. In this paper, we follow the general approach outlined in Arkes et al. (2008) to estimate time trends in heroin price, purity, and expected price per pure gram of heroin.

¹Data is unvalidated DEA data in the sense that the data we use is raw and it is possible that errors remain in the database. We cleaned the data to reduce errors as much as possible.

The raw STRIDE data covers January 1990 through December 2008. There are 100,123 observations. We follow Arkes et al. (2004)'s method to clean the data. We drop observations if the method of acquisition is not by purchase, seizure, or lab seizure (deleting 136 observations). We drop observations that are from U.S. territories (Guam, Puerto Rico, etc.) rather than states (2188 observations). We drop observations where the purity is above 100 percent (6 observations). We keep observations with zero purity, since our price and purity analysis depends on the expected purity, rather than the actual purity of heroin.²

Heroin is given a drug code based on the type of heroin. For our main analysis, we use observations for heroin hydrochloride (9200.005) and heroin base (9200.000), which according to Arkes et al. (2004) cannot easily be distinguished by the consumer.³ These types of heroin account for 82 percent of observations. We perform a separate analysis for heroin salt undetermined (9200.9), which accounts for 16 percent of observations and may be physically different from heroin hydrochloride and base.⁴ The remaining 2 percent of observations (heroin citrate, tartrate, and other) are dropped from the analysis. We refer to the combined hydrochloride and hydrochloride base observations as heroin "HCL/B" and the salt undetermined observations as heroin "SU" throughout the paper. Additionally, we focus on retail level heroin prices. Thus, observations are restricted to amounts of 1 gram or less. In addition, due to the possibility of imprecise purity measures for small amounts of heroin, we remove observations of less than 0.1 gram (22,128 observations).⁵ We are then left with 26,348 observations for our analysis (22,091 for heroin HCL/B and 4,257 for heroin SU).

Figures 5 and 6 show kernel density estimates of heroin purity and price respectively. Heroin HCL/B has a more evenly distributed purity compared to the low level of purity of

²Actual purity is the objective purity value as tested by the DEA. Expected purity is the subjective belief of the heroin consumer as to the purity of purchased heroin based on multiple purchases in the same heroin market. We assume that expected purity is the average purity of heroin purchased in a given year and location.

³This is likely "white powder" heroin. Heroin hydrochloride and heroin base are used differently by the consumer, in that base needs an addition of acid to make it soluble. However, they likely have similar effects at similar volumes.

⁴This is possibly "black tar" heroin. The salt undetermined observations are generally not part of the HSP, so one cannot easily determine the place of origin. Most of the observations come from Washington, D.C. and are otherwise spread throughout the US. Since black tar heroin is predominantly found in the western US, this heroin is likely not only black tar heroin.

⁵All estimates are robust to including observations of less than 0.1 gram.

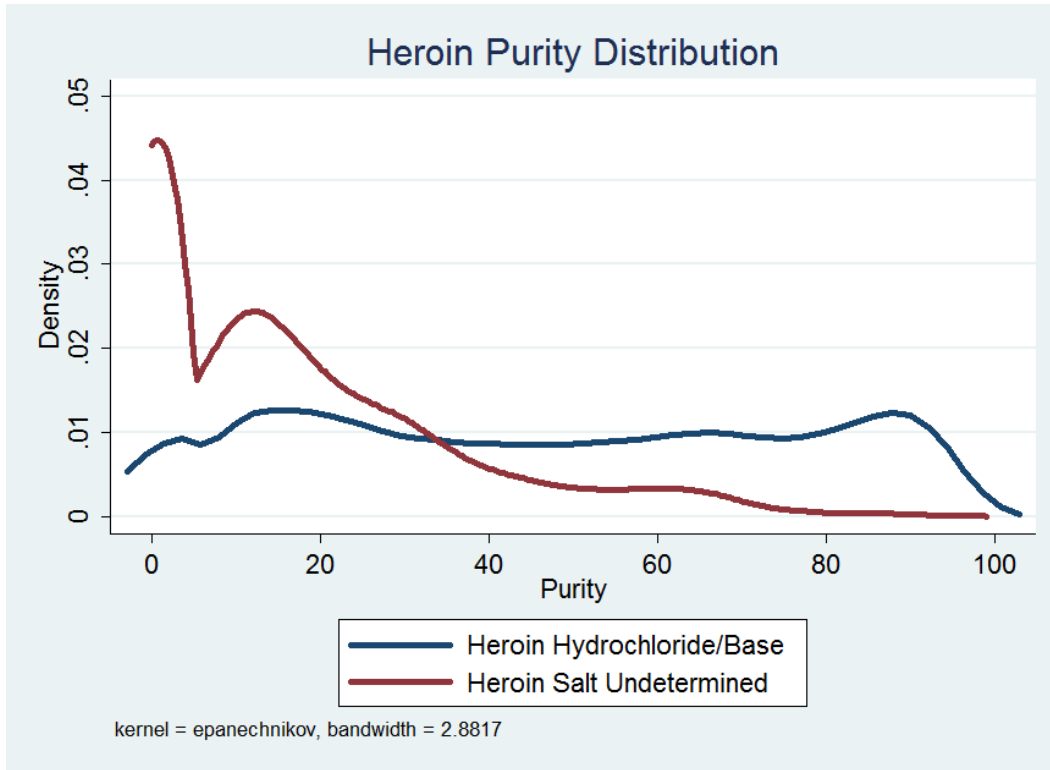


Figure 5: Purity kernel density estimate of heroin HCL/B and heroin SU for amounts between 0.1 and 1 gram. Data Source: STRIDE Database.

heroin SU. The price distributions show that heroin HCL/B tends to have a higher price than heroin SU. Thus, the analysis of heroin SU is of a lower-quality and less expensive heroin.

4 Market Competition

The STRIDE data has information on four regions of origin (Mexico, South America, South-west Asia, and Southeast Asia). We use the yearly proportion of observations from each origin region at the national level, US census region level,⁶ and the MSA level⁷ as a measure of market

⁶The 9 census region are: Pacific (AK, CA, HI, WA, OR), Mountain (AZ, CO, ID, MT, NM, NV, UT, WY), West North Central (IA, KS, MN, MO, ND, NE, SD), West South Central (AR, LA, OK, TX), East North Central (IL, IN, MI, OH, WI), East South Central (AL, KY, MS, TN), South Atlantic (DC, DE, FL, GA, MD, NC, VA, WV), Middle Atlantic (NY, NJ, PA), and New England (CT, MA, ME, NH, RI, VT). We omit the East South Central region from our analysis because of the low number of observations for this region.

⁷The MSAs are: Atlanta, Baltimore, Boston, Chicago, Dallas, Denver, Detroit, Houston, Los Angeles, Miami, New York, Philadelphia, Portland, San Diego, San Francisco, Seattle, St. Louis, and Washington, D.C. We drop MSAs with fewer than 500 observations. However, we combine the remaining observations by census region to create seven additional units. (As in the regional analysis we drop the East South Central region. We also combine the West North Central and East North Central regions to get a sufficient number of observations.)

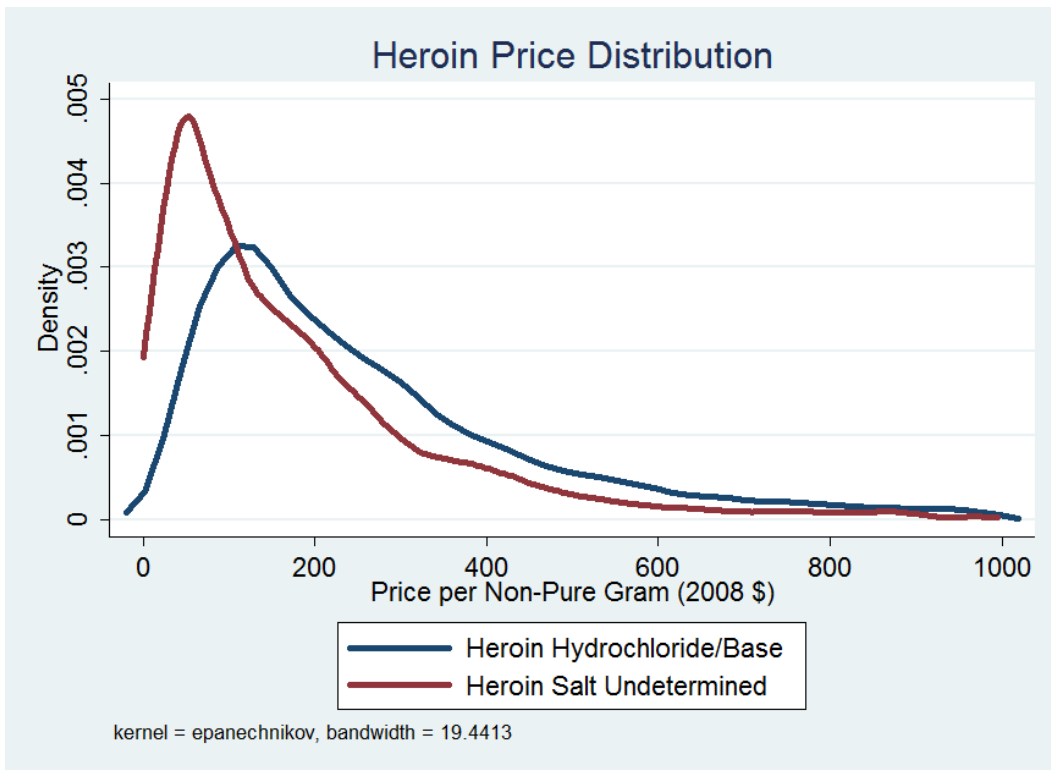


Figure 6: Price per non-pure gram kernel density estimate of heroin HCL/B and heroin SU for amounts between 0.1 and 1 gram and prices between \$0 and \$1000 per non-pure gram. Data Source: STRIDE Database.

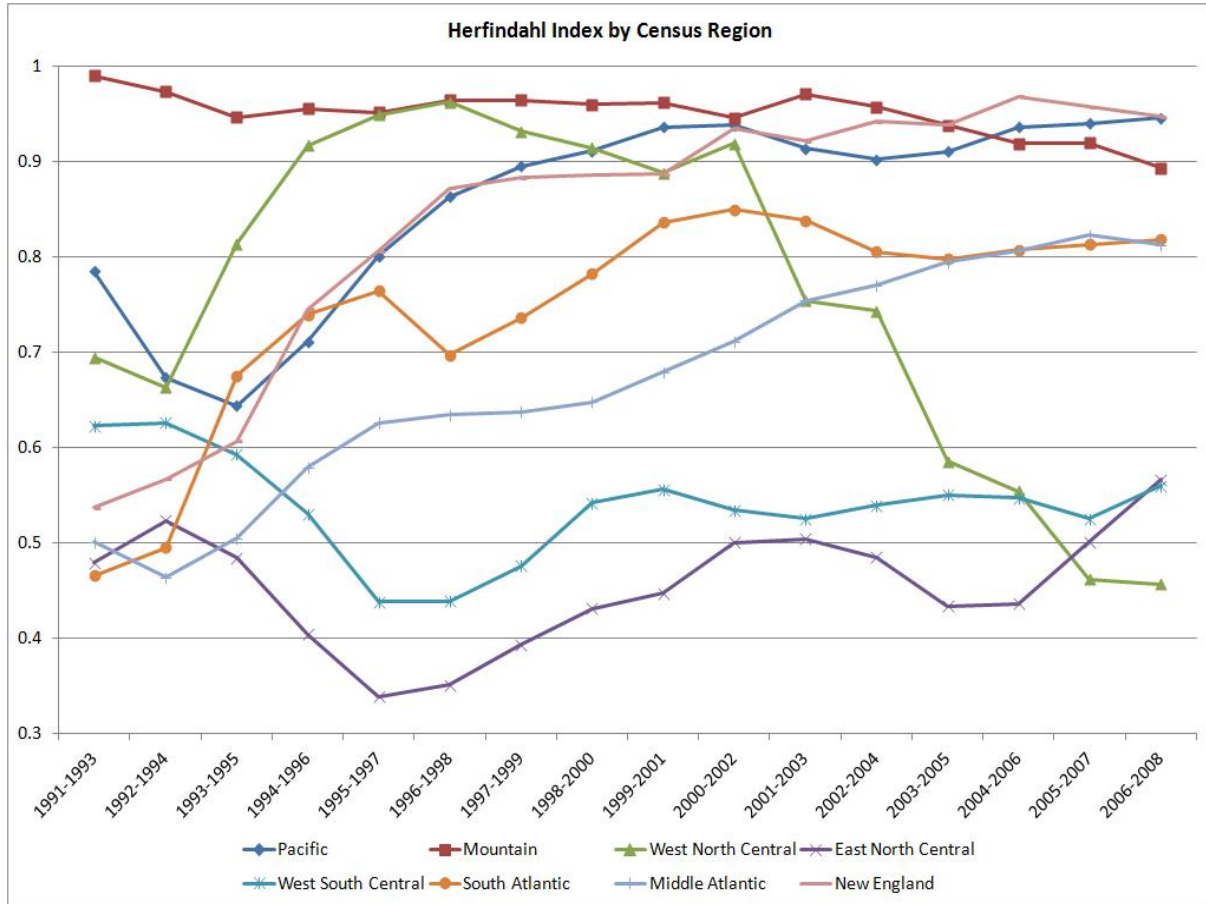


Figure 7: Herfindahl Index for the heroin market by census region, smoothed 3-year averages. Data Source: STRIDE Database

share. We then construct a Herfindahl Index (HI) from the market shares within a location. The HI is a commonly used measure of market competitiveness, with a higher HI indicating less competitiveness. The HI is calculated by summing the square of each supplier’s market share. The HI ranges from 0 to 1, where 0 represents perfect competition and 1 represents monopoly.

Nationally, heroin became more competitive following the entry of Colombian heroin in the mid-1990s (with a low HI of 0.3 in 1993) and then grew steadily less competitive to an HI of 0.5 by 2003, where it has leveled off (see Figure 8). The regional trends shown in Figure 7 give more detail about what was happening. These trends follow a geographic pattern with wide variation in competitiveness over time. The market has become highly concentrated (HI > 0.8) on the east and west coasts with competitiveness remaining higher and somewhat stable (HI between 0.4 and 0.6) in the center, with the exception of the West North Central region

becoming highly concentrated between 1996 and 2002 (HI close to 1), but then becoming significantly more competitive after 2002 with an HI close to 0.5 in 2008. The western part of the US has, for the most part, had a Mexican heroin monopoly. The east coast lost its supply of Asian heroin, effectively creating a Colombian heroin monopoly. The center of the country is characterized by the exit of Asian heroin, but the increased presence of Mexican and Colombian heroin.⁸

5 Estimation Strategy

Following Arkes et al. (2004), we use the estimated price per expected pure gram as our measure of market price. Because heroin is unregulated, purchasers do not know the purity of the heroin before it is consumed. Thus, dealers may, purposefully or not, sell low purity heroin to unsuspecting drug users. Given this information asymmetry, we assume that frequent heroin buyers are purchasing heroin with an expectation about the quality of that heroin. As in Arkes et al. (2004), we estimate the price per expected pure gram by using a two-stage estimation. The first stage is to estimate the purity in a location-year. The second stage is to estimate the price in a location-year conditional on the estimated purity. We add a third stage in which the estimated price per pure gram is correlated with the level of market concentration.

There are three levels of analysis: national, regional, and MSA level. Arkes et al. (2004) use a two-stage general linear random effects model at the MSA level which allows for general time trends to affect all the MSAs. The regional and MSA level results below are robust to this estimation method, but for simplicity we only report the estimates from an ordinary least squares method. Since we treat each location as a distinct market, when estimating price and

⁸The average HI is much larger in the regional and MSA estimates compared to the national estimates. A mathematical example will help to explain why this should be the case. Assume there are only two regions with an equal number of observations and they each have a 50-50 split between Mexican and Colombian heroin. The HI of each region is 0.5 and the national HI would also be 0.5. If the regions are instead highly concentrated, one with all Mexican heroin and the other with all Colombian heroin, they would each have an HI of 1. However, the national HI would remain at 0.5. Thus, a rise in market concentration in a region will have a large effect on that region's HI, but not necessarily the national HI. Note that if a region or MSA flipped from one type of heroin to another, for example from 10 percent Mexican heroin and 90 percent Colombian heroin to 90 percent Mexican heroin and 10 percent Mexican heroin, the HI would not change. Thus, we measure the availability of multiple types of heroin, rather than the components of these types.

purity we only include time effects within location rather than across locations. General time effects are then included in the estimated correlation between competition and location-specific price per expected pure gram.

Within each market (i.e. the whole country, the census region, or the MSA), purity is estimated as:

$$purity_{it} = \alpha + \beta amount_{it} + \gamma_t + \epsilon_{it} \quad (1)$$

where $purity_{it}$ is the purity of heroin observation i in year t in a specific market. $amount_{it}$ is the amount of heroin observed in grams, γ_t are year fixed effects, and ϵ_{it} is the error term. Price per expected pure gram within a market is then estimated as follows:

$$\ln(price_{it}) = \alpha + \beta \ln(\widehat{puregrams}_{it}) + \gamma_t + \epsilon_{it} \quad (2)$$

$price_{it}$ is the inflation adjusted price and $\widehat{puregrams}_{it} = \widehat{purity}_{it} * amount_{it}$, where \widehat{purity}_{it} is the estimated purity from Equation 1. A location-price-year level dataset is then constructed, where each observation includes the estimated price per pure gram for 0.5 grams of heroin in a given year and location.⁹

The last estimation equation correlates the price per pure gram with market competition:

$$\widehat{pricepure}_{jt} = \alpha + \beta HI_{jt} + \psi_j + \gamma_t + \epsilon_{ijt} \quad (3)$$

where $\widehat{pricepure}_{jt} = \frac{\widehat{price}_{jt}}{\widehat{purity}_{jt} * amount_{jt}}$ evaluated at $amount_{jt} = 0.5$ is the estimated price per pure gram in location j in year t . HI_{jt} is the location-year HI.¹⁰ ψ_j are location fixed effects.

The national estimates (where there is only one j) show us the aggregate correlation between market competition and the heroin price. Location and year fixed effects are not included in these estimates as they would absorb all variation in the data. These estimates show us the effect of Colombia's entry on the US market as a whole. For the regional and MSA estimates, time and location fixed effects control for general time trends in prices across all locations and normalizes each location to its own initial price level. Since the price levels may

⁹The choice of 0.5 grams was chosen as a convenient middle point in the distribution, as it is close to the average amount collected between 0.1 and 1 gram.

¹⁰We do not separate HI by type of heroin because they are substitutes.

not be accurate, the fixed effect estimates show the effects of competition on price trends within locations. In contrast to the national estimates, these estimates take advantage of differences across local markets which were differentially affected by Colombian heroin's entry. That is, as market competition goes down (HI goes up), we estimate the effect on the price per expected pure gram relative to the location's initial price level controlling for the national impact of Colombia's entry into the US market.

These estimates can only be interpreted as causal if one believes that changes in the measured HI are exogenous with respect to heroin price and purity and that there is no omitted variable bias. Endogeneity may exist because heroin from any given source region may be more likely to enter a high priced market or more likely to exit a low price market, which would bias our estimates towards finding a negative relationship between HI and price. Our estimates of such a negative relationship at the national level may plausibly be explained by this reverse causality, that the low prices caused Asian heroin to leave. However, that we find a positive relationship at the regional and MSA level means we may be underestimating the effect of market concentration on price.

Omitted variable bias may also exist. For example, there may be a drop in price in places with low market concentration because those happen to be places where the economy has been improving relative to the rest of the country and, thus, demand (and price) is lower. All heroin HCL/B estimates are robust to including unemployment or poverty rates as controls. Some of the heroin SU estimates are not robust to the inclusion of these controls, likely due to the lack of precision in these estimates. Thus, although the estimates give the first indication of how competition is related to heroin price and purity, we should be cautious about the causal interpretation of the estimates.

6 Descriptive Statistics

Mean values of the main variables of interest are presented in Table 1. The average estimated purity is similar across specifications, with heroin HCL/B having higher purity than heroin SU.

The price per non-pure gram of heroin HCL/B are consistently in the \$275-\$300 range. Prices are less consistent for heroin SU due to the smaller sample size for this type of heroin and a group of outliers with particularly high prices.¹¹

Table 1: Descriptive Statistics, Mean Values

	National		Regional		MSA
	HCL/B	SU	HCL/B	SU	HCL/B
market concentration (HI)	0.44	0.44	0.73	0.73	0.76
	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)
\widehat{purity} (percentage points)	38.13	21.82	37.53	27.63	39.78
	(0.98)	(0.94)	(1.20)	(1.52)	(0.83)
\widehat{price} (per non-pure gram)	275	258	297	384	288
	(17)	(18)	(10)	(32)	(8)
\widehat{price}_{pure} (per expected pure gram)	731	1217	937	2058	846
	(55)	(100)	(59)	(197)	(32)
Observations	19	19	144	144	424

Standard errors in parentheses. Prices in constant 2008 dollars. Purity and price estimated for 0.5 grams of heroin. Regional estimates are from 1991-2008 due to limited observations in 1990. MSA estimates are from 1992-2008 due to limited observations in some MSA's in 1990 and 1991. There were not enough observations of heroin SU to analyze the effect of market concentration on this subgroup at the MSA-level.

Figure 8 shows national trends in the estimated heroin HCL/B prices per expected pure gram and market concentration. Before 1995, market concentration and price were both falling. After 1995 market concentration rapidly increased and prices continued to fall, although at a slower rate. A plausible explanation for why prices did not reverse as concentration rose is that Colombian heroin was able to take over a large share of the market by providing cheaper and purer heroin. Prices leveled out once Colombian heroin established a large market presence in the early 2000s.

Figure 9 shows the census region trends in the estimated heroin prices per expected pure gram and market concentration. These graphs show the significant variation in price and competition across the country. The west and east parts of the US show similar trends. There was a fall in concentration in the early 1990s, followed by a rapid rise. The exception is the Mountain

¹¹For the regional values, if the 7 observations with $\widehat{price} > \$1000$ are dropped, the mean of \widehat{price} falls to \$318. If the 14 observations with $\widehat{price}_{pure} > \5000 are dropped, the mean falls to \$1418.

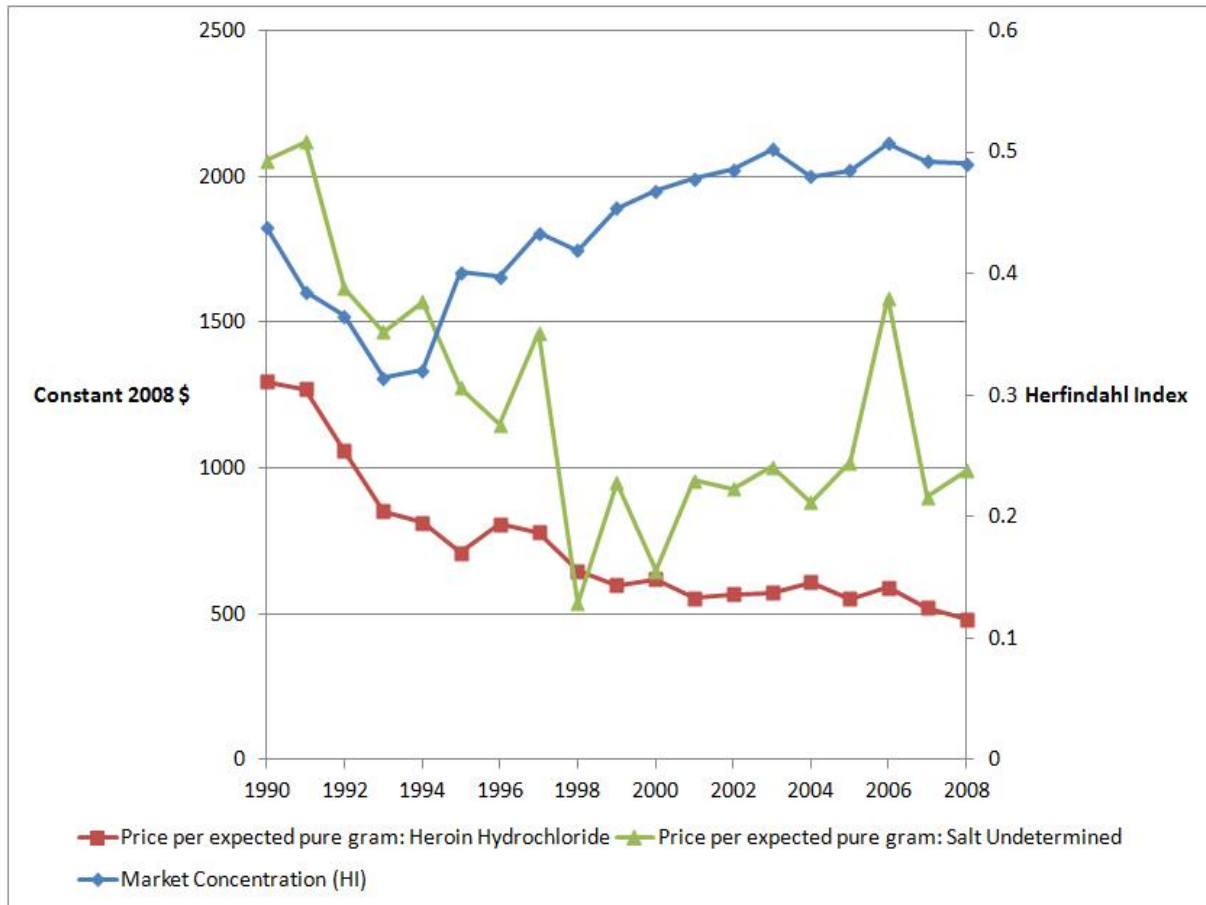


Figure 8: National estimates of trends in heroin prices and market concentration. Data Source: STRIDE Database

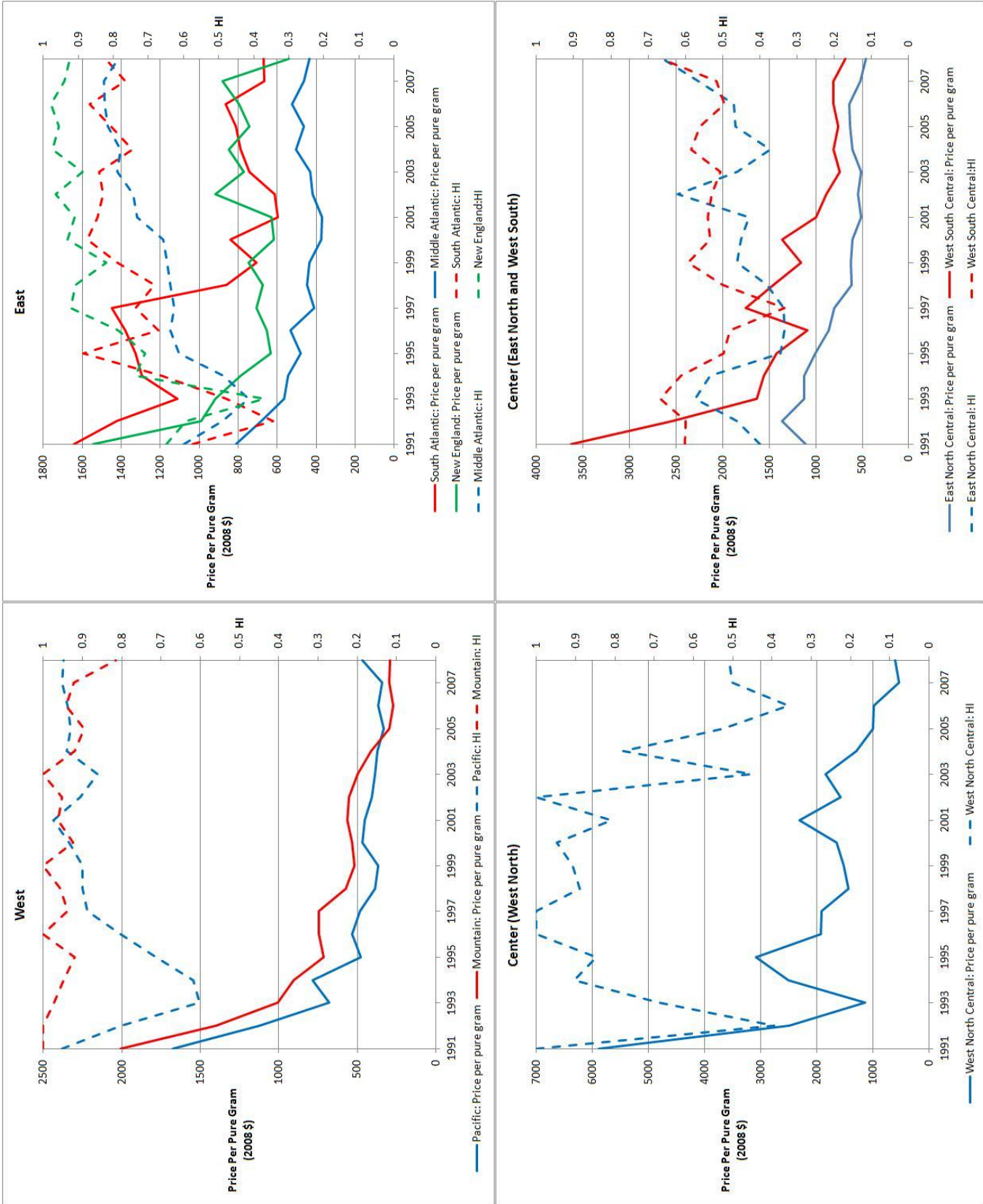


Figure 9: Regional estimates of trends in heroin HCL/B prices and market concentration. Data Source: STRIDE Database

region which has been highly concentrated throughout the time period, with a drop in the last few years. On either side of the US, concentration and prices have converged.

In the center, there are two distinct areas. The West North Central region is the only area to have a large increase in concentration in the 1990s followed by a large decrease in concentration in the 2000s. Although prices fell substantially in the early 1990s, prices have then moved with market concentration, with relatively high prices in the late 1990s and early 2000s followed by a concurrent fall in price and market concentration in the later 2000s. The East North Central and West South Central regions have maintained a low level of market concentration compared to the rest of the country. Similar to the rest of the country, concentration and prices fell together in the early 1990s, then concentration began to slowly rise and prices stabilized.

7 Estimates

Table 2 shows the estimates of Equation 3. At the national-level, market concentration increased and the price per pure gram fell. The regional and MSA-level estimates include fixed effects that control for national changes in the heroin price. Once, the overall fall in price is taken into account, market concentration is positively correlated with the heroin price per pure gram. The coefficient for heroin hydrochloride shows that a 0.1 increase in the HI correlates with a \$243 fall in price at the national-level, but a \$138 increase in price at the regional-level and \$60 increase in price at the MSA-level. The opposite signs of the coefficients show that although prices fell everywhere with the overall increase in market concentration, they fell more rapidly in areas with more competition. That is, Colombian heroin's entry is correlated with a general fall in price, but those areas with more competition saw a larger decline in price. Those with less competition had relatively high prices. Analogously, if Pepsi starts becoming available in stores, the price of all softdrinks will fall. However, the price will fall even more in stores where both Coke and Pepsi are available, rather than stores where only one type of soft drink is sold.

We decompose the effect of market competition by estimating the correlation between com-

petition and the estimated price per non-pure gram¹² and the estimated purity. At the national level, higher competition is correlated with a fall in price. At the regional and MSA levels, which again include fixed effects, competition is correlated with higher purity, but not price. Thus, competition appears to occur through increased purity, not a further decline in price. A 0.1 increase in the HI correlates with a 2.8 percentage point decrease in the purity of heroin HCL/B at the regional level and a 1.1 percentage point decrease in purity at the MSA level.

8 Discussion

Using newly available data from the Drug Enforcement Agency (DEA), we update and expand on the analysis of Arkes et al. (2004) and Ciccarone et al. (2009), showing that heroin has recently become cheaper and purer in the US. We estimate the correlation between competition and the heroin price per pure gram at the national, regional, and metropolitan statistical area (MSA) level. Our main finding is that, although the price of heroin has fallen at the national level, it has fallen more quickly in areas where there is a higher degree of competition between supplier regions. This finding is important from a policy perspective because it shows that source country matters and that policy makers may be able to affect heroin price and purity by targeting source regions with the lowest costs of production and transportation.

Our estimates are the first empirical evidence of the effect of changes in market competition on heroin prices. However, we can only interpret the estimates as causal if there is no endogeneity or omitted variables bias. Regardless, the estimates show a distinct pattern, consistent with the following story: Colombia entered the US market in the mid-1990s on the east coast and supplied large amounts of cheap, pure heroin. The low prices (combined with lower production of opium from Southeast Asia) led to the exit of Asian heroin. The supply of heroin from this new source was enough to reduce the price per pure gram of heroin throughout the country. With Mexican and Colombian heroin as the remaining major sources of heroin, locations with greater availability of both types of heroin, i.e. with more competition, had lower prices.¹³

¹²This price is the estimated price in Equation 2 before converting to price per expected pure gram.

¹³An alternative story is that Mexican and Colombian heroin suppliers are not competing, but rather are acting

Table 2: Effect of Market Concentration on Heroin Price and Purity, 1990-2008

	National Estimates		Regional Estimates		MSA Estimates	
	Heroin HCL/B	Heroin SU	Heroin HCL/B	Heroin SU	Heroin HCL/B	Heroin HCL/B
Price Per Pure Gram						
Market Concentration	-2432*** (777)	-3471** (1554)	1383*** (258)	3278** (1269)	595*** (200)	
Regional Fixed Effects	no	no	yes	yes	no	
MSA Fixed Effects	no	no	no	no	yes	
Year Fixed Effects	no	no	yes	yes	yes	
Observations	19	19	144	144	424	
R-Squared	0.37	0.23	0.77	0.51	0.45	
Price Per Non-Pure Gram						
Market Concentration	-1057.35*** (156.38)	-1022.55*** (208.48)	-6.16 (40.64)	108.10 (239.8)	-7.83 (47.21)	
Regional Fixed Effects	no	no	yes	yes	no	
MSA Fixed Effects	no	no	no	no	yes	
Year Fixed Effects	no	no	yes	yes	yes	
Observations	19	19	144	144	424	
R-Squared	0.73	0.59	0.81	0.33	0.53	
Purity (percentage points)						
Market Concentration	-21.95 (16.55)	-19.56 (15.91)	-28.34*** (5.32)	-22.02** (9.61)	-11.23*** (3.67)	
Regional Fixed Effects	no	no	yes	yes	no	
MSA Fixed Effects	no	no	no	no	yes	
Year Fixed Effects	no	no	yes	yes	yes	
Observations	19	19	144	144	424	
R-Squared	0.09	0.08	0.77	0.53	0.72	

Standard errors in parentheses. Prices in constant 2008 dollars. Regional estimates are from 1991-2008 due to limited observations in 1990. MSA estimates are from 1992-2008 due to limited observations in some MSA's in 1990 and 1991. There were not enough observations of heroin SU to analyze the effect of market concentration on this subgroup at the MSA-level. Purity and price estimated for 0.5 grams of heroin.
 (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$)

Hence, Colombia's entry led to both a reduction in competition and price, and at the same time, those regions with more competition had an even lower price relative to less competitive regions.

The analysis shows that there were two stages to the entry of Colombian heroin. The first was that cheap, pure heroin was able to facilitate the exit of Asian heroin and reduce competition overall. In the short-run this is a bad outcome from a policy perspective, increasing the use of heroin. The second stage was the establishment of a regional monopoly. Less competition eventually causes a more expensive and lower quality product. Thus, the lack of competition on the coasts may drive heroin prices up in the long-run.

We find that a rise in the price per pure gram at the regional and MSA level takes the form of higher purity rather than a lower price per non-pure gram. This finding is consistent with the phenomenon of "dime bags", heroin sold in small quantities for \$10. The price of a dime bag has, by definition, not changed over time. The quantity of heroin in a dime bag has not changed much, leaving purity as the dimension which heroin sellers use to increase or decrease the price per pure gram. This information is particularly important for policy makers because it means that prices that do not take into account purity will miss the most important changes in the heroin market.

There is considerable evidence that interdiction efforts focused on decreased supply simply shift production and distribution patterns without substantial effects on consumption. The market evidence presented here is somewhat consistent with that interpretation, namely there are a number of market participants willing and able to compete for the US market, and greater competition for consumers results in an increased quality of heroin. On an international level, Paoli et al. (2009) explain that there is a "balloon effect" where the disruption of heroin from one source is somewhat futile because it only causes a new producer to appear elsewhere. The evidence presented here suggests that heroin product is fungible at a national level as well. All of this is to say that it is difficult to reduce sources of supply without providing incentives for

as a colluding forward-looking duopoly which keeps the price of heroin low to increase future demand. However, this would not explain why the price of heroin is lower where both types of heroin are present compared to where they have monopoly control of a market.

other potential market participants to enter. However, our research also suggests that eliminating suppliers which have particularly inexpensive costs of production and transportation, may cause an increase in price even if new suppliers emerge. The one obvious avenue that would affect all suppliers would be to reduce consumer demand for heroin.

In terms of policy, our research has two major implications. First, preventing a new supplier from entering the US market can keep the price high. Thus, assuming interdiction works at reducing heroin production, intervening in a source country with particularly low production and transportation costs should be much more effective than intervening in high cost countries. Second, holding the number of suppliers to the US constant, the fewer the sources of heroin in a region or city, the higher the price. Mexican heroin's monopoly on the west coast and Colombian heroin's monopoly on the east coast is likely causing higher prices than would be the case if both types of heroin were sold in equal shares in every city. Within the US, places with more competitive illicit drug markets and, thus, low prices, may be the ones that need the most intervention.

We are still left with several questions. How did Colombian heroin take over the east coast market? Did Asian heroin leave peacefully or was it pushed out through violence? Is crime falling in places with less competition? What are the implications of reduced heroin prices for health and poverty outcomes? Is this era of inexpensive heroin telling us something about resilience to increasing demand among vulnerable populations? As a beginning of this research agenda, we have shown that competition in the heroin market is not very different than competition in other markets: entry of a low-cost competitor reduces the price and greater competition lowers the price further.

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