Prices and Federal Policies in Opioid Markets*

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Abstract

More than a dozen Federal policy changes since the year 2000 have affected incentives to prescribe, manufacture, and purchase both prescription and illicitly-manufactured opioids. To the extent that one of the policies, the 2013 "Holder memo," had a meaningful effect on the cost structure of suppliers of heroin and illicit fentanyl, standard consumer theory predicts that the trend for opioid-involved fatalities would proceed in distinct phases. Prior to 2013, subsidies to, and conveniences for, prescribers and consumers would increase total opioid consumption by reducing the full price of Rx. More surprising is that, with heroin relatively cheap of late, any Rx opioid policy could – and likely does – have the opposite total-consumption effect after 2013 than it would before, especially when the more expensive Rx opioid products are most affected. Subsidies to benzodiazepines (an opioid complement) increase opioid consumption in both phases. While policy changes at first reduced the full price of Rx, and then later increased it, technological change in illicit markets is also a relevant factor over the longer term.

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I. Introduction

In both 2015 and 2016, U.S. life expectancy fell from the previous year. A single year drop had not happened in 22 years, and two consecutive drops had not occurred in more than 50 years. The sharp reversal in the national trend toward longer lives is widely understood to be connected to the opioid epidemic, whose costs have been estimated to be about a half trillion dollars per year in recent years.[1] The purpose of this paper is to document the numerous Federal opioid policy changes since the year 2000 and to quantify their incentives using standard consumer theory.[2]

Two elements of the traditional economic approach deliver conclusions contrary to conventional wisdom. The first is the distinction between average and marginal prices in markets where consumer purchases have an element of fixed cost. A naïve application of the law of demand would suggest that opioid consumption would be discouraged by increasing the price of one of the opioid alternatives. However, consumers can switch to an alternative with a lower marginal price, which encourages them to consume more. It is possible that the additional consumption by switchers dominates the aggregate consumption response, especially when the alternatives differ significantly in terms of their marginal prices. Because so many Federal opioid policies are specific to one alternative or another, it follows that the consumption and mortality effects of one of them cannot be understood, even approximately, in isolation from the others.

Figure 1 shows why such unconventional behavioral responses should not be a surprise in the context of opioid markets. The vertical axis measures, on a logarithmic scale, the relative

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[1] Council of Economic Advisers (October 2019), which considers additional healthcare and treatment costs, criminal justice costs, reduced worker productivity, and, especially, lives lost valued at the Federal "value of a statistical life." CEA's cost estimate does not include any offset for "consumer surplus."

[2] Opioids include prescription painkillers such as oxycodone (an active ingredient in Oxycontin and Percocet) and hydrocodone (an active ingredient in Vicodin) as well as morphine and illicitly-manufactured drugs such as heroin and illicit fentanyl.

out-of-pocket price of the two main opioid alternatives: illegal heroin (including fentanyl mixes) and prescription (Rx) opioids.[3] Between 2005 and 2013, a given expenditure bought, on average, only slightly more morphine equivalents of prescription opioids. Although a switch from Rx to heroin during this timeframe would not increase the switcher's consumption, it might increase mortality to the extent that heroin is more dangerous (Appendix II). However, Figure 1 shows that for many years heroin and Rx coexisted at quite different prices. In 1992, a given expenditure bought five times as much Rx whereas in 2017 it bought only one third. If consumption is at all sensitive to marginal prices, a switch to heroin can be expected to significantly reduce consumption if it occurred in the 1990s and significantly increase consumption if it occurred after 2013.

The second unique element is the distinction between legal liability and economic incidence. As Jaffe et al. (2019, p. 3) put it, "The market-equilibrium approach says that the most important effects of policy, technical change, and other events are not necessarily found in the immediate proximity of the event." In the context of opioid markets, equilibrium means that Federal sentencing reform not only affects the "low-level drug offenders" at risk of arrest but also the market price, quality, and aggregate consumption of the illicitly-manufactured opioids that they are trafficking.[4] Equilibrium analysis also says that financial incentives for hospitals can affect the opioid consumption of individuals who may never visit a hospital. Moreover, the arithmetic of tax wedges shows how legally distinct policy wedges at various points in the opioid supply chain can be accumulated and summarized as a single wedge for the purposes of quantitative analysis.

The economic literature has a good start on measuring effects of particular opioid policies at specific points in time. Alpert, Powell and Pacula (2018) and Evans, Lieber, and Power (2019) look at changes in prescription products intended to reduce opioid abuse. Buchmueller and Carey (2018) measure effects of state prescription-drug monitoring programs. Behavioral effects of naloxone, a drug that can reverse opioid overdose, are estimated by Doleac and Mukherjee (2018) and Rees, et al. (2019). Insurance coverage effects are estimated by Zhou, Florence and Dowell (2016), Soni (2018), Powell, Pacula, and Taylor (2017), and Council of Economic Advisers (April 2019). Advertising and internet access are examined by Jena and Goldman

[3] Appendix I provides more details on the price measurement.
[4] The quote, but not the economic reasoning, is from Holder (2013).

(2011) and Nguyen, Bradford and Simon (2019). This paper takes an important next step, which is to show how many individual policies fit together in a simple overall structure. The common metric of tax wedges – familiar from public finance, macroeconomics (Mulligan 2012), international trade (Hummels 2001), industrial organization (Harberger 1954), and other fields – is part of that structure. By measuring wedges and linking policies to prices, the analysis allows quantitative policy relationships to be established between policy effects that are easier to measure and policy effects that are not. Doing so also reveals a health-economics application of the Lucas (1976) critique: there may be no such thing as "the effect" of a specific opioid policy because even its direction depends on other policies toward substitutes and complements.

In the tradition of Friedman (1966), this is a positive paper, describing what is happening, rather than a normative one describing what ought to happen. For example, even a causal interpretation between the correlation between Federal sentencing policy and the price and quantity of illicitly-manufactured opioids is consistent with opposite normative conclusions. One conclusion is that reduced sentences simultaneously benefitted drug dealers and their customers. Another conclusion is that nonmedical opioid consumption was already too high, and that sentencing reform aggravated a bad situation.

Section II of this paper reviews the standard consumer theory, which emphasizes that the effects of prescription policies, even directionally, depend on policies toward the supply of illicitly-manufactured opioids. The conceptual framework helps predict which policies would increase fatal overdoses, which policies would reduce them, and when. Point estimates based on fatality-share and price data suggest that the elasticity of aggregate overdose fatalities with respect to average prescription prices switched from negative to positive after 2015.

Policy analysis therefore requires an assessment of how the structure of prices is affected. One category of policies affects the marginal and average costs of illicitly-manufactured opioids. A second policy category affects the marginal and average costs at various points in the supply chain for prescription opioids. The third category shifts opioid demand in the sense that the policies change the prices of opioid substitutes and complements. Section III examines policies toward illicitly-manufactured opioids, especially changes in the "war on drugs." A first phase of Federal prescription policies reduced the full price of prescription opioids and the full price of a complement to all opioids, as shown in Section IV. Section V looks at a second policy phase in which the full price of prescription opioids was increased somewhat, which Sections II and III predict might further increase opioid consumption because they apply during years with low marginal prices of prescription alternatives. Section VI returns to Section II's conceptual framework, documenting the degree to which its predictions are driven by income effects as opposed to "rational" consumer behavior.

The primary data sources used in this paper measure opioid prices, sales, and overdose fatalities. Prescription sales and invoice price time series for 1992-2016 are from FDA (2018), which it compiled from IQVIA National Sales Perspectives. Prescription out-of-pocket prices are from Council of Economic Advisers (April 2019), which it compiled from the Medical Expenditure Panel Survey for 2001-2015. Heroin prices are from United Nations Office on Drugs and Crime (2018) and the various Drug Threat Assessments published by the U.S. Drug Enforcement Administration, as well as supplementary estimates made by Council of Economic Advisers (April 2019). Fatalities are from the Multiple Cause of Death Files (MCOD) 1999-2018 (National Center for Health Statistics 1999-2018), which contain all of the death certificates in the United States. I select only those records where the cause of death is unintentional drug poisoning, which are ICD-10 codes X40, X41, X42, X43, X44, X60, X61, X62, X63, X64, X85, Y10, Y11, Y13, Y14, and Y352. I further limit the death records to those in which opioids are listed as immediate or contributory causes of death (ICD-10 T codes 400/opium, 401/heroin, 402/other, 403/methadone, 404/synthetic). I take opium, heroin, and synthetic as illicitly-manufactured and the other two T codes as Rx opioids.

II. Opioid Policies and the Consumer Budget Set

The model has preferences over two commodities: opioids and "all other goods." The rate of exchange between the two commodities is the full price of opioids, which includes not only the out of pocket cost but also consumer time, effort, hassle, or stigma. To the extent that some of the costs are less than proportional to the quantity of opioids obtained by a consumer, such costs are reflected in my analysis in terms of the intercept of the budget constraint rather than the slope. I distinguish two broad categories of opioids – prescriptions (Rx) versus illicitly manufactured (Im, especially heroin and fentanyl) – entirely through the budget set rather than treating them as distinct commodities in consumer preferences.[5] Ignoring the possibility that a single consumer purchases Rx and Im opioids at the same time, I therefore model opioid purchases as a nested decision: first a choice between Rx and Im and second a quantity choice.

II.A. Why Opioid Consumption Might Increase with Prescription Prices

Figure 2 shows Im with a greater fixed cost to consumers (measured on the vertical axis) but potentially a lower marginal price.[6] In this case, which Figure 1 suggests may describe opioid markets after 2013, higher-quantity consumers would choose Im over Rx (e.g., Figure 2's allocation C), while lower-quantity consumers would choose Rx over Im (such as allocation B). The surprising result is that Rx consumers near the margin with Im, such as consumers with the indifference curve shown in Figure 2, respond to a *small increase* in the Rx price by consuming *sharply more* total opioids. The small price change shifts choice from allocation B to allocation C, which has less utility and less Rx consumption but more total opioid consumption (all of it Im). If enough consumers were near the margin, the small price increase could increase aggregate opioid consumption.[7]

Absent income effects, the aggregate demand function from Figure 2 is straightforward. Let opioid abusers (hereafter, "consumers") be heterogeneous in terms of their propensity to source from Im, but homogeneous in their mapping $H(p)$ from marginal price to consumption. Let p_R and p_I denote the marginal Rx and Im prices, respectively. $F(p_R,p_I) \in [0,1]$ is the fraction

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[5] See also Savona, Kleiman and Calderoni (2017) for analyses of parallel legal and illicit markets. Consumer preferences in my model do not distinguish Rx opioids consumed by the owner of the prescription from diverted opioids that prescription owners sell into a secondary market, although primary and secondary prescriptions are part of my analysis of Rx-Im price differentials. Schnell (2018) looks in detail at the market for reselling Rx opioids.

[6] Im marginal prices can be low because, for example, the Im sector does not pay taxes and spends little on packaging. On the other hand, illegal sellers forgo some economies of scale in order to avoid detection by law enforcement.

[7] Allusions to this affect appear in the literature on alcohol consumption. Higson and Kenkel (2004) note that teenagers, who face higher average prices for alcoholic beverages, are more prone to binge drinking. Figure 2 could also be applied to the seatbelt studies inspired by Peltzman (1975), although those studies do not explicitly consider the case of a driver who is indifferent between wearing a seatbelt or not.

of consumers sourcing from Im, which is increasing in the marginal Rx price and decreasing in the marginal Im price.[8] Aggregate opioid consumption D is:

$$D(p_R, p_I) = F(p_R, p_I)H(p_I) + [1 - F(p_R, p_I)]H(p_R) \tag{1}$$

For $p_R < p_I$ and, assuming for the moment that Rx opioids have no fixed costs, $F(p_R,p_I) = 0$ (all opioids are sourced from prescriptions) and $D(p_R, p_I) = H(p_R) > H(p_I)$. Marginal changes in the Rx price trace out H because they do not cause any consumer to source from Im instead. For $p_R \geq p_I$, two very different Rx prices maximize total consumption at $H(p_I)$. One is $p_R = p_I$, and the other is a value for p_R so large that all opioids are sourced from Im. It follows that total consumption slopes down, but less elastically than H, for low Rx prices and slopes up for higher ones.[9]

Even if Rx opioids have fixed costs too, the formula for the point elasticity of aggregate consumption with respect to p_R shows why the unconventional price effect is indeed likely in opioid markets. From equation (1), the aggregate elasticity is an expenditure-weighted average of the point elasticity of H, which is negative, and a combination of cross-price and arc elasticities. The sign of the aggregate elasticity satisfies:

$$Sign\left[\frac{\partial \ln D(p_R, p_I)}{\partial \ln p_R}\right] = Sign\left[\frac{1-r}{r} CROSS \frac{ARC}{POINT}\left(\frac{p_R}{p_I} - 1\right) - 1\right] \tag{2}$$

where $r \in (0,1)$ is the Rx quantity share evaluated at marginal prices, CROSS > 0 is the cross-price elasticity of aggregate Im demand with respect to the Rx price, ARC < 0 is the arc elasticity of H between the two prices, and POINT < 0 is the point elasticity of H.[10]

[8] Recognizing the effects of fixed costs and prices of opioid substitutes and complements would add to the notation but not the dimensionality of the model because F reflects the marginal consumer's indirect utility functions associated with Rx and Im consumption, respectively. As such, every additional price term comes with an additional theoretical restriction from Roy's identity.

[9] There will be an odd number of local minimums for total consumption but, like a Laffer curve, the aggregate demand curve is most simply illustrated in the case in which there is only one local extremum.

[10] The combination of the r and CROSS terms is, in the neighborhood of $p_R = p_I$, itself the cross-price elasticity of Rx demand with respect to the marginal Im price.

Aggregate consumption must slope down with p_R in the neighborhood of $p_R = p_I$, although aggregate mortality may not.[11] However, Figure 1 suggests that the two prices have at times been different enough to potentially make aggregate consumption slope the other way. Take the year 2016, when on average p_R/p_I was 2.2 and the mortality data suggest that $(1-r)/r$ was about 2.0. If the arc and point elasticities were equal, then any cross-price elasticity (among opioid abusers) 0.5 or more in 2016 would imply that aggregate consumption was increasing in the Rx price.[12] Repeating the calculation for Rx consumers making their purchases in the more expensive secondary market (about 13 times as expensive as heroin in 2015), the critical cross-price elasticity is tiny.

The sign of the effect of Rx prices on total opioid consumption varies over time and by policy because the price term in equation (2) varies over time and by policy. Rx opioids were once known as "hillbilly heroin" or "poor man's heroin" (Butterfield 2001, Jayawant and Balkrishnan 2005, Quinones 2015), while recently heroin is recognized to be the cheaper alternative (Cicero, Ellis and Surratt, et al. 2014, Cicero, Ellis and Kasper 2017, National Academies of Sciences, Medicine and others 2017). Moreover, Rx opioid sources are heterogeneous in terms of prices. Figure 3, whose sources are detailed in this paper's Appendix I, provides some evidence on out-of-pocket opioid prices for the year 2015. The prices are expressed in morphine gram equivalents, under the assumption that all of these products are abused primarily because they have morphine-like symptoms. Heroin (without fentanyl) and Rx opioids purchased at the pharmacy cost roughly the same out of pocket in 2015, but with some noteworthy differences. The first difference is that prescriptions have quantity limits, which led to an active secondary market. A consumer without a prescription, or topping off his prescription, obviously has his marginal Rx price equal to the (illegal) secondary market price,

[11] Appendix II's derivation of equation (2) also allows for the demand function *H* to differ between the two alternatives due to differential safety properties, shows that the sign of the price elasticity of aggregate mortality adds a third term to equation (2) that does not disappear at $p_R = p_I$.

[12] If Rx consumers varied in terms of price responsiveness and only the elastic shift to Im, then the unconventional result is even more likely because, in effect, ARC exceeds POINT in magnitude. To assess orders of magnitude of CROSS, note that Stehr's (2005) estimates of illicit cigarettes in the U.S. finds, in my notation, that CROSS*$(1-r)/r$ is about 0.7 even though (i) the illicit sector's share is much less in cigarette markets than in opioid markets and (ii) Stehr did not focus on heavy smokers.

which Schnell (2018) measured to be about six times the pharmacy price.[13] A second difference between heroin and Rx is that the Rx cost is often paid by insurance, in which case the out-of-pocket price of Rx was about $64 per MGE.[14] Using Schnell (2018)'s estimated shares of misused Rx opioids in 2014, that puts the all-sources Rx average out-of-pocket price at about $336 per MGE.

As long as marginal prices are no greater for Im than for Rx, Im prices reduce total opioid consumption, which is qualitatively consistent with a naïve application of the law of demand. However, the magnitude of the effect is more surprising because marginal prices increase with the Im price more than the Im prices themselves. Specifically, those who shift from Im to Rx see their marginal price increase by the gap between the Rx and Im prices. With the jump in his marginal price, the marginal consumer's quantity consumed jumps in proportion to his Hicksian price elasticity of demand and the log difference in the marginal prices of Rx and Im.[15] Both of these comparative statics are relevant to understanding the opioid epidemic because, as shown below, Federal policies increased Rx prices and shortly later reduced Im prices.

Because of the fixed costs, policies that uniformly increase demand for opioids will also increase the share of opioids sourced from Im. The switchers from Rx to Im experience a reduction in their marginal price, which further increases their consumption. The full effect of policy on consumption includes not only effects conditional on source but the change in total consumption that comes from switches between Rx and Im. Applications of this result are the naloxone distribution policies mentioned in Section VII.

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[13] The marginal price would also be higher for a consumer prescribed enough for his own consumption but potentially selling into the secondary market.

[14] Schnell estimates that 94 percent of Rx opioid prescriptions in 2014 were covered by insurance. As noted by Council of Economic Advisers (April 2019), this percentage is significantly less in earlier years, especially prior to 2006. Schell (2018) also estimates that, in 2014, about equal numbers of misused opioids were obtained directly from the pharmacy versus in the secondary market.

[15] Note that, even in a more general framework with income effects on consumer demand, the quantity change by the marginal consumer still has no income effect in the Hicksian sense.

II.B. Evidence that Many Opioid Abusers were on the Margin between Rx and Im

Figure 4 shows an alternative scenario in which Im is more costly than shown in Figure 2, and so costly that it is dominated by all of the Rx allocations on the same budget line as allocation B. Beginning at Figure 4's allocation B, a marginal increase in the Rx price would (barring the Giffen-good possibility) reduce total opioid consumption, which is the conventional result. The relative price data shown in Figure 1 suggest that Figure 2 is more applicable in recent years, and Figure 4 applicable in the earlier years. In this scenario, the chronology for consumer choices would be allocation A, B, and C.

Figures 2 and 4 could also be operating at the same time, with the former describing Rx consumers transacting in the secondary market, or Rx consumers without insurance coverage or without a generic prescription because those are consumers facing the relatively high Rx prices. Figure 4 might describe consumers having prescriptions for cheaper Rx products that have lower marginal prices than heroin on a morphine-equivalent basis. It is therefore important to assess the degrees to which consumers are on the margin between Rx and Im and that significant out-of-pocket price differences between the two sources can persist.

Prescription-opioid death rates were growing and above heroin death rates prior to 2010, during a period of time in which heroin was only somewhat more expensive out-of-pocket than prescriptions were. This may reflect significant additional costs of consuming heroin, such as costs of avoiding theft, establishing a trusting relationship with a drug dealer, a perceived risk of harming employment prospects, or fear of needles. If that additional cost were a fixed cost and by 2015 a four MGEs per month Rx consumer were paying $336 for Rx with a $147 heroin alternative (Figure 3), then by revealed preference the fixed Im cost would have been at least $750 per month. Meanwhile, the Im marginal cost is less than half of the Rx marginal cost in this example.

Other compelling evidence shows that many opioid abusers are near the margin between Rx and Im. 38 percent of overdose deaths in 2017 involving Rx opioids also involved Im opioids. Only five years earlier (2012), the percentage was only 12. From the heroin-use perspective, the National Institute on Drug Abuse reports that "A study of young, urban injection drug users interviewed in 2008 and 2009 found that 86 percent had used opioid pain relievers nonmedically prior to using heroin."[16]

Figure 5 displays fatality rate changes by age and sex after 2010, which is a timeframe coinciding with policy changes discouraging Rx consumption and encouraging Im consumption (more on this below). Most of the groups show, to varying degrees, reduced fatality rates from Rx opioids alone. The economically and statistically significant relationship with the change in the fatality rate involving any opioids is negative, which is remarkable given that the Rx fatalities measured on the horizontal axis are included as part of the any-opioid fatalities measured on the vertical axis. The OLS regression line has a slope of –1.8 (p-value < 0.001), which means that a reduction in the Rx-only fatality rate (per 100,000 population) by one is associated with 1.8 *more* opioid fatalities. Consistent with the hypothesis that many opioid abusers were near the margin between Rx and Im, the Rx-only reductions shown in Figure 5 are associated with the demographic groups for whom we might suspect comparatively low fixed costs of illicit activity: men and persons in their 20s and 30s.[17]

II.C. Estimates of the Point Elasticity of Aggregate Overdose Fatalities with Respect to Rx Opioid Prices

Equations (1) and (2) suggest that the determinants of the level of consumption, or even the level of the elasticity of source-conditional demand *H*(), has little to do with the sign of the effect of Rx prices on overall opioid consumption. Conversely, a failure of Rx prices to reduce overall consumption tells us little about the price elasticity of *H*. What really matters is the degree to which consumption shifts between sources, which may have little relation to the degree

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[16] National Institute on Drug Abuse (2018a). It further notes that, in contrast, "of people entering treatment for heroin addiction who began abusing opioids in the 1960s, more than 80 percent started with heroin." The frequency of initiation to opioid abuse via Im opioids may be increasing in recent years (National Academies of Sciences, Medicine and others 2017, Chapter 4).

[17] If Rx-only fatality rate changes are predicted in a first stage regression on sex and an age quadratic, all three of the coefficients are economically and statistically significant. The first stage adjusted R-squared is 0.75. The TSLS estimate of the coefficient on Rx-only in the all-opioids equation is –2.8 (p-value < 0.001).

to which total consumption is explained by "demand" versus "supply" factors.[18] This section uses this result to obtain estimates merely from the aggregate time series on prices and the share *r* of overdose fatalities involving Rx rather than Im opioids.[19]

Specifically, assume (i) that the Rx quantity share *r* changed over time due to some (unspecified) combination of marginal and average price changes for Rx and Im opioids and (ii) that the elasticity of *H*() is constant and equal to $\eta < 0$ in the relevant range.[20] From the definition (1) of aggregate demand, we have the value of $\frac{\partial \ln D(p_R,p_I)}{\partial \ln p_R}$ as a function of merely one parameter η, the measured share level *r* and its change Δr, and the measured price levels and changes:

$$\frac{\partial \ln D(p_R,p_I)}{\partial \ln p_R} = r\,\eta + \frac{p_I^\eta - p_R^\eta}{p_R^\eta + \left(p_I^\eta - p_R^\eta\right)r} \frac{(1-r)\,r\,\eta\,\Delta \ln \frac{p_R}{p_I} - \Delta r}{\Delta \ln p_R - \left(\frac{p_I}{p_R}\right)^{1-\eta} \Delta \ln p_I} \tag{3}$$

where Δ denotes time changes and for brevity only the marginal price terms are shown.[21] Equation (3) is derived from the partial derivative of (1) by using the total derivative of the Rx share *r* and using Roy's identify to eliminate the partial derivatives of *F* as functions of Δr and the price changes. The first term on the right of (3) is what the effect on total consumption would be if consumers did not respond by switching from Rx to Im. The second term consists of two ratios reflecting the price gap between Rx and Im and the cross-price elasticity as revealed by the observed share change, respectively. This result does not rule out the possibility that the time series of the *level* of opioid fatalities is driven by non-price "demand" factors rather than prices as long as the non-price factors are not important determinants of the share *r*.

[18] Case and Deaton (2017), Ruhm (2019), and Council of Economic Advisers (April 2019) attempt to decompose changes in the fatality rate between demand and supply factors. The latter find that both Rx and Im opioid prices fell significantly over time, so that supply factors explain at least part of the fatality changes.

[19] Fatalities involving both Rx and Im opioids are removed from both numerator and denominator for the purpose of measuring *r*.

[20] Appendix II discusses the case in which the safety of Im consumption changed over time, which presumably would change *r* even if prices were constant over time.

[21] The consumer theory implies that changes in a source's fixed cost and marginal price have the same effects on the share *r* as long as the magnitude of those changes are the same (i.e., the marginal price change is scaled inversely with quantity).

Table 1's panel A shows the empirical estimates for $\frac{\partial \ln D(p_R,p_I)}{\partial \ln p_R}$ in various years based on measured prices in the corresponding years, as they changed from the period 2009-11, and based on selected values for the source-conditional demand elasticity η ranging from –0.25 to –1.5. Notably, the sign of $\frac{\partial \ln D(p_R,p_I)}{\partial \ln p_R}$ changes as we move across a row from 2013 to 2017, which is an indicator that there is no such thing as "the effect" of Rx prices on total opioid consumption. Even the sign of $\frac{\partial \ln D(p_R,p_I)}{\partial \ln p_R}$ depends on the levels of Rx and Im prices and therefore which year total opioid consumption is measured.

The most recent estimates are positive – aggregate consumption increases with Rx prices – as long as η is no further from zero than –1.2. If empirical studies correctly conclude that the short-run price elasticity of the demand for Rx-opioids is likely between –0.5 and zero, then the relevant short-run estimates from Table 1's panel A are those in the first two rows where the total-consumption elasticity is positive by the year 2016.[22] A policy that increased 2017 Rx prices would increase total opioid consumption, at least in the short run because it sufficiently encourages switching from Rx to Im opioids.

Rx prices may reduce total opioid consumption in the long run even while they increase it in the short run due to an initial stock of Rx abusers who cannot easily quit opioids in response to the high Rx prices. Table 1 applies to this case by selecting elasticities of source-conditional demand that are closer to zero in the short run and further from zero in the long run and for new users (Becker and Murphy 1988, Pollak 1970). However, even the fourth row of the table (source-conditional elasticity of –1.5) shows the recent total-consumption elasticity to be –0.2, which means that even the long run reductions in Rx opioid consumption are largely, if not entirely, offset by increases in Im consumption.

Table 1's panel A assumes that marginal consumers are paying the average Rx price, which is perhaps an appropriate assumption for analysis of a policy that uniformly increases Rx prices. As noted below, other policies disproportionately affect the consumers of the more expensive of the Rx products. Panel B provides relevant results by assuming that the marginal

[22] Council of Economic Advisers (April 2019) reviews estimates of the price elasticity of demand for Rx-opioids.

consumer pays double the average Rx price. Panel B shows that $\frac{\partial \ln D(p_R,p_I)}{\partial \ln p_R}$ is essentially zero in 2015 but have may reached 0.4 by 2017.

As long as the relative price of Im to Rx is no greater than it was 2013-17, total opioid consumption is unambiguously reduced by the Im price. More expensive Im opioids reduce consumption not only among Im consumers, but also encouraging switching to Rx where marginal prices are higher. Panel C of Table 1 shows the numerical estimates, which are all negative.

The same price data used to estimate $\frac{\partial \ln D(p_R,p_I)}{\partial \ln p_R}$ can also be used to estimate the rate at which changes in the price structure increase total consumption per unit increase in Rx consumption. Note that no data on consumption (or mortality) levels, or their changes, are used in Table 1. The estimated "Rx multiplier" rates are negative after 2014 (Panel D of Table 1), which means that Rx consumption reductions over time are predicted to be associated with total consumption increases over time, even though Rx consumption is a component of total consumption. The predicted rate for 2017 is –1.3 (at a source-conditional elasticity of –0.5), which is similar to the –1.8 rate shown in Figure 5's cross-section even though Table 1 makes no use of cross-section comparisons.

II.D. Categorizing Public Policies

Public policies differ according to the years that they are in force and the primary types of opioid products affected. Nonetheless, the distinct columns and panels of Table 1 illustrate how various policies fit into the single framework of equation (1). Especially, public policies should be distinguished according to their incentives for Rx consumption versus Im consumption and the degree to which each applies during periods of low Im prices. The remainder of this paper examines Federal policies in this light, accumulating conclusions in Table 2. Rx incentives can be categorized more finely according to the chain of Rx production, which includes manufacturing, warehousing, shipping, prescribing, and consumer effort. The common metric of tax wedges allows for quantitative comparisons of the incentives at the various stages. The tax-wedge results are accumulated in Table 3.

The thesis of this paper is that full Rx price changes, largely due to Federal policy changes (Section IV) induced consumers to move from allocation A to B, as in Figure 4, between 2000 and 2013. Policies for analysis were identified from the Federal Register and agency press releases as described in Appendix III. These policies include "pain standards" and DEA rules affecting a health provider's marginal cost of prescribing opioids. Insurance coverage, especially Federally-subsidized insurance coverage, also reduced the full Rx price. A lower level of law enforcement, especially due to the 2013 Holder memo, shifted the Im budget set outward, thereby setting the stage for more expensive Rx opioids to further increase opioid consumption during the later period (Section V and Figure 2). I therefore begin by discussing the Holder memo in some detail.

III. The Holder Memo and the Heroin Market

As Eric Holder describes it, he and then Senator Barack Obama were mutually aware of the costs imposed on low-level drug offenders by Federal sentencing rules. They agreed on "the need for change, a need for new approaches" and seized their chance to make such changes when Obama became president and made Holder his attorney general (Breslow 2016). In August 2013, Holder issued his famous "Holder Memo" directing Federal lawyers to stop prosecuting nonviolent drug crimes (Holder 2013). The new initiative, which he would credit with ending 33 consecutive years of increases in the Federal prison population, would be called "Smart on Crime" and "nothing less than historic."[23]

[23] U.S. Department of Justice (2013, 2014) and Federal Bureau of Prisons (2020). See also U.S. Department of Justice, Office of the Inspector General (2017) and Higham, Horwitz and Zezima (2019).

III.A. Incarceration Costs as a Tax Wedge

It goes without saying that prison time is costly to the inmate. What economics has to add is that, when it comes to drug dealers, some of those costs are passed on to their customers. In other words, one of the likely consequences of reducing prosecution and sentencing of nonviolent drug dealers is that drug dealers would shift to less violent methods in order to be protected by the Holder memo. As dealers achieved lower costs by doing so, additional likely consequences are that the products they sell would become cheaper, or higher quality, and consumers would respond by purchasing a greater morphine-equivalent quantity (Becker, Murphy and Grossman 2006). Additional price reductions may also have come from a shift of competition from violence to price competition. In terms of consumer theory, price reductions shift out the Im budget line as from Figure 4 to Figure 2.

Anecdotes suggest that (i) the dealers in illicitly-manufactured opioids did shift to less violent methods and (ii) their products became cheaper and higher quality as a result. As described in the book *Dreamland: The True Tale of America's Opiate Epidemic*, a new heroin business model involved dealers who were "never violent. They never carry guns. They work hard at blending in." Its author Sam Quinones adds that "by 2014, heroin trafficking was expanding dramatically across America."

More systematically, the Federal Bureau of Prisons data show that the number of inmates peaked at 219,298 in 2013. Within three years, the number had fallen 27,128 even though it had increased in each of the 33 prior years. To assess the order of magnitude of the Holder Memo's effect on the costs of opioid supply (hereafter, a "wedge"), Table 3 therefore considers a law enforcement change of 30,000 nonviolent drug offender inmates. Valuing 16 waking hours of their days for 365.25 days per year at the Federal minimum wage, I estimate the aggregate annual opportunity cost of the pre-2013 incarceration rate to be $1.3 billion. Drug dealers also incur costs to avoid being apprehended and sentenced, which Table 3 takes to be equal in the aggregate to the $1.3 billion in opportunity costs of incarceration. From these estimates, the reduction in costs imposed on illicit drug supply was $2.5 billion per year.[24] $2.0 billion of these annual costs are allocated to the markets for Im opioids and illicit/diverted Rx opioids assuming

[24] The numbers in the text do not add due to rounding.

that none of them are for marijuana and allocating the remainder between opioids, cocaine, and meth according to consumer expenditure share estimates.[25] By these estimates, Federal sentencing reform is the single largest subsidy (tax reduction) going toward opioid transactions involving non-medical use, exceeding even the creation of Medicare Part D.

Table 3 says nothing about the degree to which inmates versus consumers bear the economic incidence but merely assesses the magnitude of the change in the wedge in opioid markets due to Federal sentencing policy. Whatever is the incidence of any wedge in opioid markets, it is proportional to the incidence of the others according to the wedge's magnitude.[26] A large penalty has larger effects than a small penalty.[27] The purpose of Table 3 is therefore to compare orders of magnitude of the penalty or subsidy wedges created by selected Federal penalties and subsidies in opioid markets, beginning with the sentencing changes initiated in 2013. Table 2 provides a more exhaustive timeline of Federal opioid policy changes.

III.B. Four time series turn in 2013

The year 2013 was a turning point for opioid fatality rates (Rx and Im combined), heroin prices, heroin usage, and Federal incarceration. Figure 6 displays the quarterly time series for unintentional drug poisonings involving opioids per one hundred thousand of population aged 16 and older. The Figure also shows as a vertical line the estimated quarter of trend break, 2013-

[25] The expenditure share estimates are from Office of National Drug Control Policy (2014). Note that my proportional allocation among drug types is conservative in light of Reuter and Kleiman's (1986) findings that heroin markets are most affected by enforcement efforts. Because the only reported opioid expenditure is for heroin, I take expenditure on illicit/diverted opioids to be the same expenditure rescaled by the relative number of overdose deaths. All of these data used for the scaling factor are for calendar year 2010.

[26] This conclusion is related to Diamond and Mirrlees' (1971) result that the taxation of intermediate goods is superfluous to taxing final goods, except to the extent that the two type of taxes have different possibilities for avoidance and evasion.

[27] By the same reasoning, \$2 billion in costs imposed on low-level drug offenders would reduce consumption at least as much as \$2 billion in costs imposed on "kingpins" upstream because the former are closer to the consumer. Whether penalizing low-level offenders is cost effective is a different question, because it depends on the policing and prosecution costs that are needed to impose each dollar of cost on the various suppliers.

Q3.[28] The estimated break happens to begin in the quarter of the Holder memo. An important component of the series in Figure 6 is the series for fatalities involving synthetic opioids (especially, fentanyl). That series shows a structural break in 2013 Q4. The break is so dramatic that the distribution of year-over-year changes between 2008 and 2013 (24 observations) has no overlap with the 12 observations after 2013.

The fentanyl fatalities coincident with the Holder memo are not merely the introduction of a dangerous drug onto roughly constant quantities of Im opioid consumption. Figure 7 displays the histogram for year-over-year changes in recent heroin usage among adults, measured quarterly from the National Survey on Drug Use and Health (NSDUH).[29] Sixty changes are shown in the Figure from the years 2003-2018. Three of the largest four changes occurred in the year following the Holder memo. Using the individual level data prior to 2015, when the NSDUH survey was redesigned, I regressed recent heroin usage on a linear time trend and an indicator for the year 2014. The coefficient on the indicator variable was 10.1 per 10,000 adults, with an OLS standard error of 2.6. By comparison, the *level* of the usage series was 16 per 10,000 adults in the early 2000s. The unprecedented acceleration of heroin usage coincident with the Holder memo is notable given that three years earlier the reformulation of the leading Rx opioid brand also encouraged Rx consumers to switch to heroin (see subsection V.B).

Council of Economic Advisers (April 2019) reports little change between 2008 and 2012 in the inflation-adjusted price (per MGE) of Im opioids. It estimates that prices were nine percent lower in 2013 (not noticeably outside the 2008-12 range), followed by drops of 22 percent and 34 percent in the next two years. CEA time series may be too short for formal structure break tests, but the changes after 2013 are substantial and did not regress back to the mean. A structural break test on the annual Federal incarceration rate per person aged 16 and

[28] The date is estimated using the supremum Wald test (Perron 2006), as implemented by STATA. The Wald statistics are similar for alternative structural breaks one quarter early, one quarterly later, and two quarters later.

[29] "Recent heroin usage" refers to usage sometime during the twelve months prior to the NSDUH interview (variable irherrc).

older shows a break in 2012, although the Wald statistic for a break in 2013 instead is a close second.[30]

To be clear, law enforcement may not be the only reason that Im opioid prices fell 31 percent between 2013 and 2016.[31] Compare Table 3's estimate of the cut in annual Federal inmate incarceration costs after 2013 of $2 billion to Table 4's various estimates of Im opioid consumption in 2013. The Office of National Drug Control Policy's (2019) separate demand and supply methods imply that 31 percent of 2013 expenditure (that is, the value of the Im price cut that would occur during the next three years) is about 3 or 4 billion dollars.[32] This consumer savings exceeds the reduction in Federal incarceration costs, although it might be similar to the reduction in the incarceration costs for state and Federal inmates combined. Alternatively, the NSDUH survey reports 75 million self-reported heroin-use days in 2013, which if undercounted by a factor of three (Morral, McCaffrey and Iguchi 2000) and supplied with $30 daily bags of heroin would be aggregate consumer expenditure of $6.7 billion. A similar estimate is obtained from Rx opioid sales by assuming that expenditure on Im opioids and Rx opioid abuse are proportional to fatalities and that 35 percent of Rx opioids are abused (see Appendix I). By these two estimates, the 31 percent quality-adjusted price cut that occurred over the next three years would save consumers roughly $2 billion, which is similar to the reduced Federal incarceration costs. Higher consumption and expenditure estimates are obtained by assuming higher rates of Rx opioid abuse, as with Table 4's final upper bound estimate. Measurement errors and a competitive response to the reduced law enforcement are reasons that the measured Im opioid price cut might exceed incarceration cost cuts. However, technological change, such as new

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[30] The Wald statistics are 179, 226, and 204 for a break beginning in 2011, 2012, and 2013, respectively. The p-values on these tests are each less than 0.0001. Of course, aside from the purely statistical evidence, we have that the Justice Department itself believed and intended that something historic was beginning with Federal incarceration in 2013.

[31] As described in Appendix I, my Im price estimates are somewhat different because I have updated CEA's source data and assumed a more conservative potency for fentanyl.

[32] Because the ONDCP demand method relies heavily on scarce data on urine test results of persons arrested, it rather aggressively scales up the self-reported drug use of persons who do not make contact with the criminal justice system. As a result, its high-end estimate imply that, implausibly, heroin consumption is an order of magnitude less fatal per MGE than Rx opioid abuse is. ONDCP lost confidence in its supply method after 2001, but I apply it to the year 2013 by using the year 2001 ratio of supply to demand to scale down demand estimates.

supply chains, has also been a factor reducing quality-adjusted heroin prices (Farrell, Mansur and Tullis 1996, Reuter and Kleiman 1986, Office of National Drug Control Policy 2020).

On the other hand, the emergence of fentanyl in the U.S. heroin market after 2013 should not be entirely attributed to a contemporaneous technological change. Fentanyl is not a new drug, even in the illegal sector. My search of Department of Justice press releases between 2001 and 2019 reveals several episodes of fentanyl entering the U.S. heroin supply before law enforcement could shut it down.[33] "From 1990 through 2005 at least nine clandestine fentanyl laboratories were seized in the United States" (U.S. Department of Justice 2006). Fentanyl was illicitly manufactured in Mexico for the U.S. market in 2006, to the point where the Office of National Drug Control Policy concluded that "drug traffickers have substantially poisoned the drug supply in the United States" by adding fentanyl to heroin.[34] Law enforcement shut down that fentanyl manufacturing, but not before fatality rates involving synthetic opioids briefly spiked 72 percent above their previous levels.[35]

Table 1 and Figure 6 provide some insight as to the role of Im opioid prices in the increased number of fatalities involving opioid overdoses. Recall that the table and figure have no overlap in their data sources: Figure 6 uses only total fatalities whereas Table 1 uses prices and the composition of fatalities. Figure 6 shows that the log of the fatality rate in 2017 is about 0.46 above the pre-2013 trend. Table 1 shows that the log of real Im opioid prices fell 0.71 between 2013 and 2017. The table's panel C shows an elasticity with respect to Im prices that varies over time, but centers at –0.33 during the period (within-source elasticity of –0.5) or –0.61 (within-source elasticity of –1.0).[36] The predicted increase in log fatalities from 2013 to 2017 is therefore between 0.23 and 0.43 above trend, which is 51 to 94 percent of the actual increase above trend. The predicted increase would be even greater if Im opioids are more dangerous per

[33] Appendix III describes the sources and search criteria I used to identify Federal policies toward opioid markets.
[34] Chicago Tribune Editors (2006). Hempstead and Yildirim (2014) argue that the technological change was the internet, which was widely used well before 2013.
[35] In 2008 DEA declared an important fentanyl ingredient as a List I chemical, subjecting it to additional regulation. In 2010, it would prohibit a more finished version of the chemical. Both of these rules are cited in Table 2.
[36] Council of Economic Advisers (April 2019) notes that a number of studies estimate the price elasticity of heroin demand to be near or exceed in magnitude, but based on Gallet (2014) use an elasticity of about –0.5 for its simulation purposes.

MGE or if we assume that consumers switching to Im would have otherwise been purchasing their opioids in the relatively expensive Rx secondary market.

III.C. A 2017 turning point?

In May 2017, the new Attorney General Jeff Sessions reversed Holder's sentencing policy (Sessions 2017). However, it is unclear whether sentencing policies have returned to what they were in the early 2000s. Using Holder's metric of the change in the Federal prison population, we see that it was negative in 2017 and negative overall between 2017 and the beginning of 2020 (Federal Bureau of Prisons 2020).

Another round of DEA rules intended to curtail fentanyl production and distribution began in May 2016. As described by the DEA (83 FR 5189), "when DEA temporarily controls a given substance structurally related to fentanyl, illicit manufacturers located abroad begin producing new such substances through other structural modifications. Those new nonscheduled substances then are smuggled into the United States, where they are distributed by traffickers in this country as a purportedly 'noncontrolled' substance." Ten DEA final rules cited in Table 2 prohibited various fentanyl analogs by putting them on Schedule I.[37] One of those rules (83 FR 5188) temporarily established a more elastic definition of a fentanyl analog, which DEA believes "substantially slowed the rate at which new fentanyl-related substances are introduced" into illicit U.S. markets (U.S. Department of Justice 2019).[38] China, which had been a principal source country, began class-wide control of fentanyl analogs in May 2019.

The quarterly opioid overdose fatality rate series also shows a reversal in 2017 Q2. The rate fell in each of the three quarters 2017Q2 through 2017Q4 after increasing in 10 of the previous 11 quarters. The rate fell again in two of the four quarters of 2018. A reversal is also obvious in the Im fatality series, which fell in 2017Q2 after increasing in 21 of the previous 22

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[37] Those rules are 81 FR 29492, 81 FR 85873, 82 FR 20544, 82 FR 26349, 82 FR 32453, 82 FR 49504, 83 FR 469, 83 FR 4580, 83 FR 5188, and 83 FR 61320. In addition, thiafentanyl, which is used for animals and is roughly 1,000 times more potent than heroin, was put on Schedule II in 2016 (81 FR 58834). Three more rules put three less potent opioid substances on Schedule I (81 FR 22023, 81 FR 79389, and 82 FR 32453).

[38] The temporary analog scheduling expires in May 2021 (Congressional Research Service 2020).

quarters. The Im fatality rate was essentially constant in 2017Q3 and fell again in two of the next five quarters.

As shown in Figure 7, recent heroin usage as measured by NSDUH shows some of the largest year-over-year drops in the year following the reversal of the Holder memo. The real per-pure-gram price of heroin was 21 percent higher in 2017 and 2018 than it was in the prior two years. However, according to the method of the Council of Economic Advisers (April 2019), this increase was more than offset (in MGE terms) by increases in the fentanyl content of heroin.

IV. CMS Subsidies for Prescribers and Patients

The Centers for Medicare and Medicaid Services (CMS), which is the component of the Department of Health and Human Services that administers the two major Federal health insurance programs (as well as the smaller although disproportionately famous "Obamacare" programs), provided financial incentives at various points in the prescription opioid supply chain. The upstream incentives relate to pain management standards that encouraged opioid prescribing. Downstream incentives were created by expanding insurance coverage that reduced the out-of-pocket cost for purchasing opioids as well as an important opioid complement. This section describes the Federal rulemaking creating these incentives and attempts to assess their magnitudes in comparison to the aforementioned incentives created by changes in law enforcement.

IV.A. Pain Management Standards

At his 1996 Presidential Address to the American Pain Society, Dr. James Campbell concluded that "[w]e need to train doctors and nurses to treat pain as a vital sign. Quality care means that pain is measured and treated." Four years later, the Veterans Health Administration (VHA) would cite Dr. Campbell as it mandated pain as "the 5th Vital Sign," which meant that pain would be routinely screened and documented with the other vital signs. Moreover, the patient's other vital signs and behavior "should not be used instead of self-report" by the healthcare provider making the pain assessment (Department of Veterans Affairs 2000).[39] Addiction was not mentioned in the VHA's 57-page toolkit implementing this new pain management strategy, other than listing "fear of addiction" as the leading implementation barrier to be addressed by healthcare providers and institutions. At its peak in 2012, the VHA would be dispensing opioid prescriptions to almost 700,000 unique patients per quarter (Good 2017). Years later, the new Secretary of Veterans Affairs would report that veterans were twice as likely to die from opioid overdose than the general population (Wilkie 2018).

The new standards would soon come into civilian practice too, with three phases of financial encouragement from CMS (Centers for Medicare and Medicaid Services 2017, Pacula and Powell 2018). CMS has long conditioned hospital reimbursement under its Medicare and Medicaid programs on adequate hospital quality, to be assessed by the Joint Commission on Accreditation of Healthcare Organizations, another accreditation organization, or state survey agencies.[40] "The Joint Commission accredits and certifies more than 21,000 hospitals, health systems, facilities and programs in the U.S. Health facilities stripped of Joint Commission accreditation could find their Medicare funding in jeopardy" (Japsen 2019). In 2001, the Joint Commission released its "original pain standards, which were applicable to all accreditation programs, stat[ing that] 'Pain is assessed in all patients'" (Joint Commission on Accreditation of Healthcare Organizations 2001) as well as the aforementioned principles of the VHA's pain management strategy. With pain management becoming part of the accreditation process, 2001 began the first phase of financial encouragement by CMS.[41]

The second incentive phase began in 2007, when CMS would withhold two percent of full reimbursement if a hospital failed to participate in a patient survey known as the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS survey).[42] Although (as of 2007) CMS reimbursement was based on survey participation but not survey results, CMS would publicize hospital-specific survey results. CMS and hospitals expected that survey results

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[39] An exception was allowed for patients unable to communicate.

[40] CMS is required "to ensure that the Joint Commission's surveying of accredited hospitals is equivalent to state agency surveying of unaccredited hospitals" (Lohr 1990, p. 131).

[41] At the same time, HHS delegated the regulation of opioids for drug treatment programs to JCAHO, including removing HHS caps on dosage and days supply (66 FR 4076) and later expanding the list of approved opioids (68 FR 27937).

[42] The November 2006 rule promulgating this requirement was 71 FR 68193. The two percent penalty come from Section 5001(a) of the 2005 Deficit Reduction Act.

would affect consumer willingness to use one hospital versus another. At this time, the HCAHPS survey included questions about the patient's pain management experience.

As described by Physicians for Responsible Opioid Prescribing (2016), hospitals were "financially incentivized by CMS to obtain high scores on HCAHPS Survey questions. The questions on the Survey pertaining to treatment of pain have had the unintended consequence of encouraging aggressive opioid use…". In other words, physicians that prescribed extra, or more potent, painkillers would tend to produce higher HCAHPS scores, and therefore additional funding, for their hospital. A 2016 article in the *American Journal of Public Health* further concluded that the financial incentive left "well-meaning professionals with the unsavory choice of prescribing opioids or facing dissatisfaction from disappointed patients on patient surveys." This CMS incentive remained for 12 years until the pain treatment questions were removed from the survey in October 2019.

The full price of opioids is lower when physicians are more willing to prescribe them. Consumers spend less time and hassle finding a physician who will give them a prescription. They receive extra pills, which by resale, gift, or theft become available to consumers without a prescription. The monetary price of Rx opioids is lower for customers in the secondary market. In terms of Figure 4, the pain standards promulgated in 2000 and 2001 are a shift from allocation A to allocation B, with the result being more opioid consumption.

If enough consumers were at the margin between Im and Rx opioids, the pain standards could reduce overall opioid consumption by shifting it from Im to Rx where the full price was reduced by the pain standards but still above the marginal price of Im (a shift from C to B in Figure 2). This does not appear to be the case between 2000 and 2005, when the death rate from heroin overdose and the quality-adjusted price of heroin were fairly constant.[43] However, if the new pain standards had been delayed ten or twelve years when there appears to be more consumers on the Im-Rx margin, it is possible that their introduction would have reduced total opioid consumption for nonmedical use for the reason shown in Figure 2.

Opioid consumption is complementary over time (i.e., opioids are addictive), which means that temporarily low prices encourage addiction that can increase consumption even after

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[43] The death rate from all overdoses had been increasing between 1980 and 2000, during which time the quality-adjusted price of heroin had fallen significantly.

prices are no longer low (Becker and Murphy 1988). If in fact the 2013 Holder memo sufficiently increased the number of nonmedical consumers on the margin between Im and Rx, the timing of pain management standards that would maximize total opioid abuse would be to encourage prescribing until 2013 at which time the encouragement would end. The greater population of consumers would then switch to Im opioids with a lower marginal price. At least Figure 2 is a warning that stricter prescribing standards might not significantly reduce overall opioid abuse as long as Im prices are low.

The third incentive phase began in 2012, when CMS implemented the "valued-based purchasing" (VBP) requirement from the Affordable Care Act. Pursuant to the law, "value-based incentive payments to hospitals were tied to the value of these patient experience performance measures, which included pain management scores as a core component" (Pacula and Powell 2018). A later CMS rule (81 FR 79571), effective October 2017, excluded the pain management scores from the VBP determinations. HCAHPS pain management questions remained part of the hospital accreditation process and were extended by the same rule to hospital outpatient facilities (81 FR 79771) via a survey known as "OAS CAHPS."

In 2016, hospital revenue from Medicare alone was $242 billion (see also Table 3). If a hospital were not accredited because it did not sufficiently adhere to pain standards, it would stand to lose that revenue as well as Medicaid revenue. It might also lose private revenue to the extent that a hospital's private demand is a function of its accreditation status. On the other hand, the hospital would either save on the costs of treating Medicare and Medicaid patients or receive another form of revenue on behalf of those patients. It might also save on the costs of adhering to the other accreditation standards. The first phase of CMS pain standard incentives therefore appears to have an annual wedge in the direction of encouraging opioid prescriptions that was potentially in the billions or tens of billions of dollars.[44]

In the second phase, 2 percent of the reimbursement would be withheld for failing to participate in the HCAHPS survey (and thereby have results publicized) even if the hospital was accredited. Because pain management was one seventh of each hospital's composite scores reported by CMS, Table 3 shows one seventh of the 2 percent of revenue, or about $0.7 billion for 2016. To be clear, Table 3 merely offers order-of-magnitude estimates because the exact

[44] The accreditation incentive remained in the latter two phases.

calculation also depends on the effect of HCAHPS scores on private revenue, which itself depends on how a hospital scores on the rest of the HCAHPS survey relative to its competitors. With these caveats, Table 3 suggests that the opioid-market wedge created by CMS incentives for pain management standards were of the same order of magnitude as the change in Federal law enforcement.

The Drug Enforcement Administration (DEA) changed its policies regarding opioid Rx in 2005, 2007, 2010, and 2014. Prior to 2005, some physicians were under the impression that monthly appointments were required for patients continuing a prescription for Schedule II substances, which now includes all opioids and then included all but hydrocodone combination products. DEA clarified in 2005 that physicians may transmit Schedule II new prescriptions by mail or fax, as long as the patient retains the original signed and dated prescription. This clarification made prescribing easier in some cases, although it may have increased the costs of prescribing for physicians who had thought DEA rules had been stricter.

In 2007, the Schedule II rules were genuinely relaxed so that physicians could provide patients with multiple postdated prescriptions in a single office visit (hereafter "refills" although technically the postdated prescriptions are not refills) for up to a 90-day supply. This change is a form of convenience, although small in the aggregate by comparison to the other policies quantified in Table 3. Based on the refill frequencies estimated by Mundkur, et al. (2019), I estimate that aggregate out of pocket spending on opioids in 2016 by patients receiving refills was only $0.5 billion.[45] Based on a study of adherence for chronic medications, I estimate that allowing 90-day prescriptions rather than 30-day (somewhat more convenience than the actual 2007 rule) has the same effect on consumption as a 37 percent reduction in the out-of-pocket price.[46] In the aggregate, that is an annual convenience value of about $0.2 billion, as shown in Table 3.

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[45] In addition to the refill frequencies, I take retail opioid sales from FDA (2018) and the out of pocket share from Council of Economic Advisers (April 2019).

[46] The Taitel et al. (2012) study of Medicaid patients receiving chronic medications found that 90-day durations for the prescriptions increased total medication picked up from the pharmacy by 20 percent. For a population with a price elasticity of demand of –0.4, motivating that quantity increase with a price reduction would require a 37 percent price cut.

In 2010, a DEA rule (75 FR 61613) allowed electronic prescriptions for opioids, which provided an element of convenience but were also expected to reduce forgeries. In 2014, DEA reclassified hydrocodone combination products, which include Norco and Vicodin, from Schedule III to Schedule II. This reclassification made those products somewhat less convenient to prescribe and dispense.

IV.B. Insurance Coverage

Consumers with prescription-drug coverage have a lower out-of-pocket price for Rx opioids than cash customers do. This is also true for Rx tranquilizers covered by insurance, which are a complement with both Im and Rx opioids. As Federal programs such as Medicare or Medicaid expand, then more consumers face the lower out-of-pocket price and Federal taxpayers pay most of the difference.

Of the various Federal coverage expansions since 2000, the largest from the perspective of the opioid market was the creation of Medicare of Part D in 2006. Prior to that date, Medicare, which is the Federal health insurance program for the elderly and disabled, did not cover retail prescription drugs. Within a year, Part D enrollment had exceeded 30 million, cutting their Rx opioid out-of-pocket price by more than 90 percent compared with no coverage.[47] Council of Economic Advisers (April 2019, Figure 12) shows that largest single-year increase in opioid prescriptions occurred in 2007.

Many of the Rx opioids paid by Medicare were consumed by consumers ineligible for Medicare. Some of those prescriptions were given away to friends or relatives. Others were stolen. Citing a family physician from Ohio, Sam Quinones' book *Dreamland* asserts that "seniors realized they could subsidize their retirement by selling their prescription Oxys [a potent opioid] to younger folks. Some of the first Oxy dealers, in fact, were seniors who saw the value of the pills in their cabinets. 'It's like hitting the Lotto if your doctor will put you on OxyContin…. People don't even think twice about selling.'" The diversion of Medicare

[47] 2007 enrollment is from Table IV.B7 of Boards of Trustees, Federal Hospital Insurance and Federal Supplementantal Medicare Insurance Trust Funds (2014). The average out-of-pocket opioid price for Medicare is from Council of Economic Advisers (April 2019, p. 6) and refers to Oxycontin.

prescriptions was significant enough that Powell, Pacula, and Taylor (2017) found that the opioid-related fatality rate among persons *ineligible* for Medicare increased significantly as a result of the creation of Medicare Part D.

Table 3 reports my estimate of the dollar amount of the subsidy wedge created by Medicare Part D in 2016. The estimate is the product of (i) Part D expenditure on opioids from the Inspector General of the Department of Health and Human Services (2019), (ii) the share of Part D overall drug spending that is reimbursed by Part D plans (Roehrig 2018), and (iii) the 35 percent share of Rx opioids that go to nonmedical use (as estimated in Appendix I). The results in Table 3 suggest that, ignoring term (iii) for the moment, the creation of Medicare Part D created the single largest change in the wedge in opioid markets. However, unlike the Federal law enforcement change, about 60 percent of the subsidy is received by legitimate medical users, which is why Table 3's calculation includes term (iii)'s abuse rate.

Medicaid also expanded eligibility during this period, especially in 2014 due to the Affordable Care Act. Council of Economic Adviser's (April 2019) estimates from the Medical Expenditure Panel Survey do not show any increase in Medicaid opioid prescriptions between 2013 and 2015. In contrast, CMS data on Medicaid claims show an additional 4.3 million opioid prescriptions over the same time frame.[48] Using the Walmart price for a month's supply of 20 mg Oxycontin tablets, and assuming a 17 percent Medicaid rebate and a 35 percent abuse rate, I enter a $0.1 billion subsidy for 2016 in Table 3.

Benzos are part of the opioid crisis because they are the other half of the opioid-benzo cocktail that is a favorite among opioid abusers. The tranquilizers "enhance" the feeling of opioid consumption. For the same reason, benzos carry serious risk of death when used in combination with opioids (Sun, et al. 2017). A study of 2,400 veterans who died from a drug overdose found that 49 percent of them had been prescribed concurrent benzos.[49] According to the MCOD files, about a quarter of opioid overdose fatalities in the general population also

[48] The CMS data also show that Medicaid opioid prescriptions fell 6.7 million over the subsequent two years.
[49] Park et al. (2015). The primarily male study sample was selected as the 112,069 U.S. veterans who received VHA prescriptions for opioids during 2004-9. Of those, 2,400 died from drug overdose during the study time frame. Also note that, prior to 2017, the FDA did not require benzo prescriptions to carry a warning about the potentially lethal opioid interactions (Food and Drug Administration 2016).

involve benzos. The most recent two years' cause-of-death data (2017-18), each show more than 9,000 opioid-benzo fatalities. Moreover, as a complement to opioids, benzos subsidies should not only be expected to increase opioid consumption but also to increase the likelihood that a consumer sources his opioids from low-marginal-cost sources, such as illicit manufacture. In other words, the scenario shown in Figure 2 is more likely with benzos subsidies than without them.

When Medicare began covering prescription drugs in 2006, benzos were specifically excluded from coverage (Bambauer, Sabin and Soumerai 2005, Centers for Medicare and Medicaid Services 2005, 2012). Section 2502 of the 2010 Affordable Care Act (ACA) requires all health plans to cover them. The requirement thereby reduced their out-of-pocket cost. The benzos mandate is therefore a significant subsidy, especially when the benzos are distributed through Medicare (Medicaid had limited coverage of them).[50] For the purposes of assessing the relative magnitude of the effect of the subsidy on opioid overdose fatalities, I take the Medicare subsidy for opioid abuse, multiply by the fraction of opioid fatalities that also involved benzos (National Institute on Drug Abuse 2018b) and rescale by the relative price of benzos to opioid at the pharmacy (TrueMedCost.com 2014).[51] Finally, to account for Im consumers with prescriptions for benzos but not for opioids, I divide by the share of opioid-benzo fatalities that involve Rx opioids as measured from the 2016 MCOD file.

V. Increasing the Full Price of Prescription Opioids

Beginning in 2010, Federal policies began to take steps to reduce the supply – or increase the full price – of prescription opioids. Early among these were the Drug Enforcement

[50] Maust, et al. (2018) find a significant overlap in 2015 between Medicare prescriptions for opioids and benzos. Not until 2017 would the prescription tranquilizers carry a mandated warning about the risks of fatal interaction with opioids (opioids include prescription drugs such as oxycodone as well as illicitly-manufactured drugs such as heroin and illicit fentanyl).

[51] The ACA benzo mandate also applies to private health insurance. Sun et al.'s (2017) study of "315,428 privately insured people aged 18-64 who … also filled at least one prescription for an opioid" found that in 2013 17 percent of opioid users also used a benzo, which was an 80 percent relative increase from 2001.

Administration's "Prescription Take-back" programs, which since 2010 have collected thousands of tons of unused prescription drugs from thousands of locations (Department of Justice 2010, Drug Enforcement Administration 2020).[52] However, one estimate suggests that the opioid share of collections is disproportionately low and that unused opioid collections are only 0.3 percent of opioid dispenses by pharmacies (Egan, et al. 2017). More noticeable in the aggregate are abuse-deterrent formulations and revised pain management standards. This section reviews these two Rx policy categories, with attention to the hypotheses derived from Figure 2, especially during the years 2014 and following when the Holder memo was affecting the Im substitutes.

V.A. Revised Pain Management Standards

CMS has acknowledged that hospitals had financial incentives, originating with CMS, to obtain high scores on the HCAHPS patient surveys that included pain management questions. CMS further acknowledged that some of those hospitals gave financial incentives to their physicians to increase the HCAHPS scores. However, in a remarkable lapse of economic reasoning, CMS assumed (most recently in 2018) that its hospital-reimbursement policies had no effect on the employment contracts between hospitals and doctors, merely because CMS did not intend or endorse any such effects.[53] Meanwhile, the financial incentives created by the hospital-quality measures were recognized by an Indiana task force assembled in 2015 by Indiana Governor Mike Pence, who would later become Vice President of the United States (Governor's Task Force on Drug Enforcement, Treatment, and Prevention 2016). In 2017 the President's Commission on Combating Drug Addiction and the Opioid Crisis (2017) concluded that CMS should end its financial incentives for over-prescribing opioids. CMS followed the Commission's recommendation, removing the pain-communication questions from HCAHPS effective October 2019 (Centers for Medicare and Medicaid Services 2019).

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[52] In 2014, DEA would also switch the final Schedule III opioid category (hydrocodone combination products) to Schedule II, which prohibits refills and is more strict on the transmission of prescription information from physician to pharmacists (Drug Enforcement Administration 2014).

[53] See especially CMS (2018, pp. 59141-3), which reiterate previous publications by CMS officials.

Earlier, VHA began its Opioid Safety Initiative in 2013, which would prove to be the beginning of a significant (at least 25 percent) decline in the number of unique VA patients dispensed an Rx opioid (Good 2017). The initiative included urine screening for opioid abuse, prescribing with tapering protocols, offering substitute treatments for chronic pain, and using state-level prescription-drug monitoring programs (United States Government Accountability Office 2018).

The 2018 SUPPORT for Patients and Communities Act included provisions for changing prescriber guidelines. It also included provisions for restricting the import of illicit drugs, reduction in regulatory barriers for treating opioid-abuse disorder, encouraging the distribution of naloxone, and increased funding for those treatments (Food and Drug Administration 2019b). The Comprehensive Addiction and Recovery Act of 2016 also included provisions in some of these general areas. The 2018 SUPPORT Act gave the DEA additional authority to tighten its annual Rx opioid production quotas pursuant to the Controlled Substances Act. However, members of Congress and the DEA debate whether the quotas meaningfully affect the aggregate quantity of Rx opioids.

V.B. Abuse-Deterrent Opioid Formulations and Takeback Days

The period 2010-12 is particularly interesting because Federal policies were increasing the full price of opioids while the available data show no significant decrease of heroin prices from what they were before 2010. After 2013, the price of Im opioids is falling below prescription opioid prices (recall Figure 1), which in theory has both a “direct effect” on heroin mortality as well as increasing the likelihood that total mortality is increased by the full price of Rx opioids. Prescription opioid prices are also increasing after 2012, especially for branded Rx opioids (Food and Drug Administration 2018). It is therefore worthwhile to revisit previously published results on policy effects during the years 2010-12 and use the demand model (1) to isolate effects of Rx policies that are coincident with changes in Im prices during the subsequent years.

Prescription opioid pills taken for nonmedical use are many times crushed or dissolved so that they could be injected or snorted (contrary to the prescribed method). With this in mind, the Food and Drug Administration (FDA) in 2010 approved new “abuse-deterrent formulation” opioids that could not be abused as easily, thereby increasing the full price of Rx opioids from the perspective of Rx abusers.[54] Schnell's (2018) analysis of IMS data show that prescriptions of OxyContin (the primary Rx opioid that was reformulated at that time) fell sharply later in the year. By January 2011, OxyContin prescriptions fell below 2006 levels. Note that, as a branded drug, OxyContin is significantly more expensive than generics. As of 2019, no generic abuse-deterrent opioid painkillers had yet been approved by the FDA (Food and Drug Administration 2019a).

Aggregate data show reductions in opioid prescriptions after 2010, and significant reductions after 2012 when multiple policies were encouraging consumers to shift from Rx to Im. FDA (2018) data show aggregate morphine equivalent opioid prescriptions in 2011 were about one percent below their 2010 peak.[55] In 2012, they were about three percent below the peak. By 2016, Rx opioids were 20 percent below their peak. Administrative data tell a similar story as to the number of prescriptions. Medicare opioid prescriptions per Part D enrollee fell 16 percent between 2013 (the peak year) and 2017 (Buchmueller and Carey 2018, Centers for Medicare and Medicaid Services 2019b). Medicaid opioid prescriptions fell 4 percent from 2015 to 2016, and another 14 percent the next year (Centers for Medicare and Medicaid Services 2019a). Express Scripts (2019), which has about one quarter of the pharmacy benefit management market (Paavola 2019), reported that opioid prescriptions fell 17 percent from 2017 to 2018 for commercial plans, 13 percent for Medicare plans, 25 percent for Medicaid plans, and 19 percent for plans on the health exchanges.

The reformulation may explain why fatal heroin overdoses increase between 2010 and 2013, at least as much as Rx deaths decrease (Alpert, Powell and Pacula 2018, Evans, Lieber and

[54] As the FDA put it, "These formulations are intended to make certain types of abuse, such as crushing a tablet to snort or dissolving a capsule to inject, more difficult or less rewarding." (Food and Drug Administration 2018)

[55] Propoxyphene + Acetaminophen, an opioid heavily prescribed for mild to moderate pain, was withdrawn from the market at the end of 2010 pursuant to a FDA recommendation (Food and Drug Administration 2010). DEA classified it as Schedule IV "with a low potential for abuse and low risk of dependence." For the purposes of this paper, it does not matter whether or how much this withdrawal versus OxyContin reformulation caused the shift from Rx to Im.

Power 2019), even though heroin did not appear to become cheaper during that time.[56] As shown in Table 1's 2013 column, their finding does not necessarily mean that opioid consumers are price insensitive but rather that reduced consumption among Rx consumers who do not switch to Im is partly, if not fully, offset by increased consumption by those who do switch. While Evans, Lieber and Power (2019) find a structural break in 2010 for the heroin fatality rate, the structural break for total opioid fatalities occurs later, coincident with the 2013 Holder memo (Figure 6).[57]

The increase in heroin usage after 2013 appears to significantly exceed the increase that occurred after 2010 (Figure 7). Although we do not have estimates of the amount of the full price increase associated with reformulating extended-release Oxycontin to compare with the Im price reductions coincident with the Holder memo, it is clear that Im price reductions apply to a larger quantity than reformulation did. The reformulation of extended-release Oxycontin appears to have reduced its annual sales by less than 22 million MGE by 2013 (Food and Drug Administration 2018). As discussed below, heroin consumption in 2013 is estimated to be between 69 and 172 million MGE. Moreover, the lesson from Figure 2 is that the reformulation and reduced law enforcement reinforce each other in terms of reducing Rx opioid consumption and increase total opioid consumption.

Note that consumers were switching away from Rx opioids that were among the most expensive on the primary market, and therefore more expensive than the average Rx opioid featured in Figure 1 (Food and Drug Administration 2018). As shown in Figure 3, marginal price reductions would be even greater for consumers switching away from secondary-market OxyContin. Table 1's panel B is therefore the panel most applicable to reformulation, suggesting that raising Rx opioid prices by themselves would hardly reduce overall opioid consumption in 2013. It suggests that reformulation may be increasing total consumption in the more recent years even if it had mildly negative effects in 2013.

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[56] Note that 2013 and 2014 are the most recent years used by Alpert Powel and Pacula (2018) and Evans, Leiber and Power (2019), respectively, to measure the aggregate mortality effect of the reformulation.

[57] A pattern of opioid addiction originating with prescription followed by a switch to more potent heroin when prescribing practices were tightened has historical precedents. Writing before the most recent episode became apparent, Cartwright (2001, Chapter 4) describes the same pattern early in the 20th century.

To the extent that they deplete supply to secondary markets, "Prescription Take-back" programs are also policies that disproportionately affect higher-priced Rx opioids and therefore more likely to have the unconventional effect of increasing total opioid consumption. Because the programs may be too small in the aggregate to statistically detect the direction of their effect (Egan, et al. 2017), the findings regarding abuse-deterrent opioids may be the best evidence available as to the effects of the programs.

In contrast, state-level prescription-drug monitoring programs (PDMPs) operate on all Rx opioid products, even the cheaper ones. Studies have found that PDMPs reduce Rx abuse as measured by a single patient using many prescribers and pharmacies (Rhodes, et al. 2019), but show mixed results in terms of a statistically significant change in opioid fatalities (Buchmueller and Carey 2018). Of the studies available so far, few use data after 2012, when the relative price of heroin is low and in principle PDMPs could be increasing mortality.

VI. The Role of Income Effects

The applicability of rational choice to the demand for addictive drugs is a matter of vigorous debate. The argument against notes that drugs cause "persistent changes in the brain structures and functions known to be involved in the motivation of behavior" and that frequently "the addict expresses a desire not to consume drugs prior to, after, or even during the drug intake" (Henden, Melberg and Rogeberg 2013). However, both sides of the debate acknowledge budget constraints, which are at least half of the rational choice model of consumer behavior. Using a random demand model with linear budget constraints, Becker (1962) shows that market demand for a commodity slopes down even when the market lacks any rational consumer.[58] For example, an addict spending all (or any fixed share less than one) of his income on a drug would have unit-elastic demand: doubling the price would require him to reduce consumption by a factor of two.

[58] Conversely, the fact that an addict reduces drug consumption in response to higher prices is not proof of rationality (Becker and Murphy 1988).

Figures 8 and 9 extend Becker's constant-budget-share analysis to the two-part budget constraint. As the Rx opioid price varies by itself, two levels of consumption of all other goods are consistent with a single budget share, depending on whether opioids are sourced from Rx or Im.[59] These two levels are shown as horizontal blue lines in Figure 8. I assume that consumers do not choose a dominated point on the budget constraint (that is, a point where more of both goods can be purchased), and achieve the fixed budget share in the Rx market whenever the dominance criteria does not distinguish between Rx and Im. Beginning with a low Rx price (less than p^*), marginal increases in price reduce opioid consumption with an elasticity of negative one, moving the allocation horizontally along Figure 8's upper horizontal line toward allocation B. As the price passes p^*, opioid consumption jumps up from q_B to q_C. Further increases in the Rx price have no effect on opioid consumption because opioids are sourced from Im.

Figure 9 shows this "irrational" demand curve in quantity-price space together with the rational demand curve for a consumer having Cobb-Douglas preferences with share parameter equal to the irrational consumer's fixed budget share. For Rx prices less than $p_L < p^*$, both theories of demand generate the same a unit-elastic curve. For Rx prices greater than p^*, both generate the same fixed quantity q_C. The difference is that the rational consumer switches from Rx to Im before Rx is strictly dominated. The irrational consumer holds out until the Rx price exceeds p^*, at which point the discrete increase in opioid consumption is greater than the increase made by the rational consumer at price p_L.[60] Using only income effects and the idea of dominance, Figures 8 and 9 thereby strengthen the unconventional prediction that increasing Rx opioid prices increases opioid consumption over the range in which consumers switch from Rx to Im. Moreover, the properties of the aggregate demand function (1) used in this paper do not depend whether consumers are assumed to be "rational" as in Figure 2 or "irrational" as in Figure 8.

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[59] Here I assume that the budget share is applied to income net of the black-market fixed cost. The net income would be disposable income if part of the fixed cost accrued in the form of a monetary fine, less employment, or lower-paying work.

[60] In other words, relative to the rational consumer, the jump in the irrational consumer's opioid consumption is disproportionate to the sensitivity of opioid consumption to the Rx price at prices below. The rational consumer's jump from point B to C in Figure 1 is just a movement along a single Hicksian demand curve, whose substitution properties are reflected in the Marshallian demand curve shown in Figure 9 for Rx prices below p_L.

VII. Conclusions

Opioid markets have been affected by large Federal subsidies, broadly defined to include cuts in taxes, penalties, and compliance costs. In 1999, opioid expenditures for nonmedical use were less than 5 billion in 2016 dollars. Over the next 17 years, a greater amount of new opioid-abuse subsidies would take effect (Table 3), which at 1999 quantities would be enough to make opioid abuse essentially free at retail. With subsidies of this magnitude, it is unreasonable to expect that opioid abuse would have remained constant after 1999 even if there had been no outward shift in the nonmedical demand for opioids.

Roughly $2 billion of the $5 billion total annual subsidy for opioid abuse was a reduction in the opportunity costs of drug offenders in Federal prison that began in 2013, which this paper documents for the first time. Additional cost reductions, not included in the $5 billion, came at about the same time with reduced prosecution of drug crimes by states. Measured as a change in the tax wedge, the Federal law enforcement policy alone is likely larger than each of the Medicare subsidies and the changes in prescriber norms that have been documented in previous studies (Soni 2018, Council of Economic Advisers April 2019, Adams, Bledsoe and Armstrong 2016).

This is also the first paper to comprehensively catalog the dozens of Federal opioid policies, which it identifies in twenty years of the Federal Register and from the Department of Justice press releases. A single economic framework is provided to represent each of these policies. The analysis captures both phases of the opioid epidemic and the role of public policy in transitioning from one phase to the next. It further shows how reducing the supply costs of illicitly-manufactured (Im) opioids is a particularly potent way to encourage nonmedical opioid use because, in addition to reducing Im prices it also causes consumers to switch away from prescription (Rx) opioid products with relatively high marginal prices. I estimate that, in this way, falling Im prices explain the majority of the increase in opioid fatalities above trend after 2013, which has been the particularly alarming phase of the epidemic. Although it is clear that something significantly reduced Im prices after 2013, the quantitative results for fatalities are subject to the caveat that price changes in illegal markets are difficult to measure precisely.

The same analysis also helps explain the “puzzle” as to why policies beginning in 2010 that increased the full price of Rx opioids nonetheless failed to reduce opioid fatalities. The key insight from economic theory is that there is no such thing as “the effect” of an Im policy or “the effect” of an Rx policy. The direction and magnitude of these effects depend on the price differentials between the Rx and Im segments of the market more than they depend on the price sensitivity of total opioid demand. Prior to 2013, Im opioids were more expensive on the margin, by as much as a factor of five in the 1990s. Now I estimate that by 2017 Im opioids cost, on average, just a third at retail of what Rx opioids cost due to the presence of illicitly-manufactured fentanyl in the heroin supply. Policies that increase the full price of Rx opioids in 2017 are likely increasing overall abuse, even though the same policy might have significantly reduced overall abuse a decade earlier.

The same approach has potential for resolving debates in the literature as to the mortality effects of policies that increase the supply of naloxone, which is “a medication designed to rapidly reverse opioid overdose” (National Institute on Drug Abuse 2018). There is not only the question of whether a life-saving effect of naloxone holding opioid abuse constant is offset by an increase in the amount of abuse (Doleac and Mukherjee 2018, Rees, et al. 2019), but also the composition of that abuse between Rx and Im. Even if naloxone had the same mortality effect per equivalent quantity of Rx as Im, the fact that it increases the quantity of opioid consumption by itself encourages a shift from Rx to Im where marginal prices are now lower.

There is much more to be learned about opioid markets. Opioids are addictive, which raises interesting questions as to market dynamics given that actual policies took effect at various points in time. Something akin to technological change or expanded international trade has at times been an important driver of illegal drug prices. For example, real heroin prices fell by a factor of three in the 1990s (United Nations Office on Drugs and Crime 2018). With such reductions in costs, nonmedical use of opioids and other illegal drugs may never return to the levels that they were years ago.

VIII. Appendix I: Measuring Opioid Abuse Quantities and Prices

This appendix provides the details of my estimates, and others, of the amount of Rx opioid abuse, the amount of heroin and fentanyl consumption, and the prices of Rx and Im opioids.

VIII.A. Estimates of Opioid Abuse

The National Survey on Drug Use and Health (NSDUH), overseen by the Department of Health and Human Services, interviews individuals to obtain self reports of nonmedical drug use. In 2010, for example, NSDUH finds that almost five percent of adults used Rx painkillers for nonmedical purposes during the twelve months prior to the interview. On average, those adults abused opioids 47 days during that year, which makes for a nationwide total of 522 million person-days of abuse in a twelve-month period. Assuming that Rx-opioid abusers consumed the same number of morphine-equivalents as a bag of heroin (0.162 MGE), that makes 85 million MGEs of opioids consumed by abusers in the U.S. That puts Rx opioid abuse at 35 percent of national Rx opioid sales.[61]

Under the assumption that, per MGE, Rx opioid abuse is no more fatal than consumption of Im opioids (see also Appendix II), I obtain an upper bound on aggregate MGE consumption of Im opioids. Specifically, Im consumption is bounded above by the Rx consumption of opioid abusers times the ratio of Im fatalities to Rx fatalities. The Rx consumption of abusers is itself

[61] On average for calendar years 2009 and 2010, 240 million MGEs of opioids were sold annually, including those for medical use and those that went unused (Food and Drug Administration 2018). These are also years in which heroin and Rx opioids were similarly priced (recall Figure 1). For comparison to the 0.162 MGEs abused per person-day, note that the average daily prescription for persons who died from opioid overdose was 0.030 MGEs (Hirsch, et al. 2014). Because following the prescription is, by definition, not abuse, I assume that abusers consume more than 0.03 MGEs per day of abuse. Also note that self-reports likely underestimate the prevalence of abuse (Johnson and Fendrich 2005, Morral, McCaffrey and Iguchi 2000, Office of National Drug Control Policy 2012, Caulkins, et al. 2015).

bounded above by aggregate Rx sales, which itself includes waste and legitimate medical use. Take the year 2013, where FDA measures aggregate Rx opioid sales to be 226.8 million MGEs. Using the fatality ratio, that bounds Im consumption at 172 million MGEs (Table 4). If we assume further than Rx abuse is no more than 35 percent of aggregate Rx consumption, the Im consumption bound for 2013 is 60 million MGEs.

Building up from drug tests and self-reports, the Office of National Drug Control Policy (ONDCP) estimates that heroin consumption was 25 pure metric tons in 2001 and 24 metric tons in 2010 (Office of National Drug Control Policy 2014). The major hole in this approach is determining how much heroin is consumed by persons not interacting with the criminal justice system, which ONDCP assumes to be undercounted in NSDUH by a factor of four. However, the Figures 7.7 and 7.8 from the same source noted that half of U.S. heroin originates in Columbia, whose potential production is only 11.4 metric tons in 2001. Actual production destined for the U.S. is less, and about 3 metric tons are seized before it reaches consumers. That puts 2001 U.S. consumption less than 20 metric tons (100 million MGEs), which is 21 percent less than what ONDCP (2012) estimated by building up from drug tests and self-reports.[62] To put it another way, arithmetic requires us to accept at least one of these four conclusions: (i) ONDCP's estimates of heroin consumption are substantially exaggerated, (ii) heroin consumption is significantly *less* fatal per MGE that Rx opioid abuse, (iii) the FDA substantially underestimates the production and dispensing of opioid prescriptions, or (iv) heroin fatalities are significantly underestimated relative to deaths involving Rx opioids. With conclusions (ii) and (iii) particularly implausible, and (iv) at least surprising, I am left with conclusion (i).

VIII.B. Time Series for the Relative Price of Rx and Im Opioids

Using IQVIA National Sales Perspectives, FDA (2018) compiled prescription opioid sales and invoice price time series for 1992-2016. The FDA calculations do not reflect third-party payments that put out-of-pocket prices below invoice prices, especially in more recent years. On the other hand, they do not reflect secondary market prices, which are much greater

[62] ONDCP (2012) acknowledges the large and consistent discrepancy between its two approaches but discards its production approach because reliable production data are no longer available.

than pharmacy invoice prices (more on this below) but are only available for two years. The FDA calculations are used for my Figure 1, except that generic and branded are reweighted to reflect in 2011 the relative changes in the two types of Rx opioids between 2010 and 2015 as the market was substituting toward Im. The generic weight evolves over time in proportion with the market-wide average generic share as reported by FDA (2018).

The Drug Enforcement Administration (DEA) collects heroin prices as a byproduct of its efforts to prosecute offenders and to monitor the drug supply. The estimated prices vary widely according to the size of the transaction and how (or whether) the sample is reweighted in attempt to represent the average consumer rather than the average prosecution. The reweighted averages tend to be much lower, but are not consistently reported for long periods of time. Moreover, it is known that regular customers receive substantial discounts, which DEA agents are often not receiving (Arkes, et al. 2008, Jacques, Allen and Wright 2014). Another concern for comparing quality-adjusted marginal Rx and Im prices is that Im opioids are not only more potent due to chemical makeup but also that they tend to be administered differently (intravenously).[63] Of course, becoming a regular customer or learning a new method of administration have their costs but for the purposes of my analysis fixed costs of this type must be distinguished from marginal costs.

In order to minimize exaggeration of the marginal heroin price for regular customers, I use the long time series assembled by United Nations Office on Drugs and Crime (2018) from DEA and other sources because its heroin prices somewhat less than the long time series published by ONDCP (2019).[64] It is adjusted for fentanyl content using the method of Council of Economic Advisers (April 2019), except that I updated some of its data sources and assumed a more conservative 15-to-1 ratio for the potency of fentanyl versus pure heroin. The adjustment

[63] National Academies of Sciences, Medicine and others (2017, Chapter 4).

[64] The percentage changes over time are similar among the various sources. The exception is after 2015, where DEA has more of an increase in heroin prices per pure gram than other sources do. In order to be conservative as to the reduction in heroin prices in recent years, I splice the DEA series onto the UN series after 2015.

is minimal for most prior years to 2014.[65] By 2018, it reduces the Im opioid price by 66 percent relative to pure and unmixed heroin.

Because the UN heroin prices are still high compared to the reweighted (but not durably available) series from DEA, I suspect that the relative price of heroin shown in Figure 1 and Table is still somewhat exaggerated. The important and more robust conclusion is that heroin was significantly more expensive than Rx in the 1990s and is now significantly cheaper.

VIII.C. Out-of-Pocket Opioid Prices by Source, Circa 2015

For the purposes of Figure 3, I take the Walmart pharmacy Oxycontin price of $134.27 for 30 days of 20 mg, as reported by TrueMedCost.com (2014) in 2014. This dose is used because it is the modal oxycodone prescription in Hirsh et al.'s (2014) sample of patients who died from Rx opioid overdose. Using a morphine conversion factor of 1.5 for oxycodone (Centers for Disease Control and Prevention 2018), the Rx price without insurance is $149.19 per morphine gram equivalent (MGE). To estimate the out-of-pocket price with insurance of $64.15 per MGE, I take a coinsurance rate of 43 percent, which is the average among the Medicare Part D plans in the sample of Einav, Finkelstein and Schrimpf (2015).

Drawing from StreetRx crowdsourced data, Schnell (2018) reports a 2014 average price for Rx opioids of $880 per MGE on the secondary market.[66] Schnell estimates market shares among Rx opioid misusers for primary Rx cash, primary Rx with insurance, and free "from friend or relative," which I use to weight the three aforementioned Rx-price estimates for an all-sources average of about $336 per MGE.[67]

[65] During the aforementioned fentanyl episode of 2006, the adjustment reduces the Im opioid price by 21 percent relative to pure and unmixed heroin.

[66] Schnell further explains how the StreetRx data have been validated with law enforcement data. Converted to 2014 dollars per MGE, the street price for Oxycontin reported by Butterfield (2001) is $860. A third source (Dasgupta, et al. 2013), based on StreetRx for 2012, finds Oxycontin to cost $667 per MGE (2014 dollars) on the secondary market.

[67] Schnell estimates small percentages for stolen, which I exclude for the purposes of calculating weights. Medicaid is treated as free and the Einav et al. average coinsurance rate is applied to all other insured.

DEA (2018) reports that a pure gram of heroin cost $724.50 in 2014, which is about $144.90 per MGE. Anecdotes from Quinones and others refer to "$15 bags" of heroin, which is about 1/10th of a gram (a morphine conversion factor of 5). Even if such bags were only 36.7 percent pure, that would be $81.74 per MGE.[68] Note that the heroin price (U.N. data before adjusting for fentanyl mix) used in Figure 1 implies an implicit "per bag" price of about $17 in 2014.

Fentanyl is about 15 times more potent than heroin (Wikipedia 2020). Referring to DOJ data from before 2017, Council of Economic Advisers (April 2019) reports that fentanyl costs somewhat less per gram at wholesale, and therefore at least 15 times cheaper per MGE. The degree to which an increase in fentanyl supply reduces equilibrium retail prices per MGE depends on supply constraints and how fentanyl is distributed to final consumers. Using the methods cited above, I estimate that mixing heroin with fentanyl cut retail MGE prices by 25 percent between 2013 and 2015. Applying this factor to the pure-heroin prices cited above, I estimate the 2015 heroin-fentanyl price to be between $59 and $104 per MGE.

[68] If a bag is taken to be a daily dose of heroin, and the bag is 36.7 percent pure (the average reported by DEA for 2014), then the daily dose is about 0.18 MGE. By comparison, the modal daily extended-release oxycodone prescription in Hirsh et al.'s (2014) sample of overdose fatalities was 0.03 MGE and the smallest was 0.015 MGE.

IX. Appendix II: Adding Safety Differentials to the Demand System

The main text of the paper uses equation (1) to analyze fatal rates under the assumption that nonmedical opioid consumption, measured in morphine-gram equivalents (MGEs) is proportional to fatality rates. The purpose of this appendix is to extend the model to include the common assertion (Drug Enforcement Administration 2016, Frank and Pollack 2017, Ciccarone, Ondocsin and Mars 2017) that Im opioid consumption is more dangerous per MGE than Rx opioid consumption.

Let $m \geq 1$ denote the extra mortality associated with each Im MGE consumed and $\mu \leq 0$ denote the elasticity of MGE demand with respect to m, holding constant the retail price. The modified model of opioid consumption becomes:

$$D(p_R, p_I) = F(p_R, p_I, m)m^{\mu}H(p_I) + [1 - F(p_R, p_I, m)]H(p_R) \tag{4}$$

The corresponding model of opioid fatalities is, up to a factor of proportionality:

$$\widehat{D}(p_R, p_I) = F(p_R, p_I, m)m^{1+\mu}H(p_I) + [1 - F(p_R, p_I, m)]H(p_R) \tag{5}$$

Note that the safety differential has offsetting effects on Im mortality, so that the mortality elasticity with respect to m, can have either sign. Indeed, as revealed by policies to enhance the safety of opioid abuse, $1+\mu$ is close enough to zero that researchers cannot agree on its sign (Doleac and Mukherjee 2018, Rees, et al. 2019). If $1+\mu$ were exactly zero, then the model (5) is essentially the same as the model (1) used in the main text, except that equation (1) would have to be interpreted as calculating "mortality-gram equivalents" rather than morphine-gram equivalents.[69]

The model (5) has three terms in its formula for the elasticity of aggregate mortality with respect to the Rx price:

[69] Table 1 assumes that changes over time in F are due to price changes rather than nonpecuniary factors, which is consistent with the model (5) if m is constant over time. To the extent that the safety differential increased over time, Table 1 understates [check] the effects of prices on F because they are partially offset by changes in m.

$$\frac{\partial \ln \widehat{D}(p_R, p_I)}{\partial \ln p_R} = -r\,\eta - (1-r)ARC\,\frac{CROSS}{m^{1+\mu}}\left(\frac{p_R}{p_I} - 1\right) + (1-r)CROSS\,\frac{m^{1+\mu} - 1}{m^{1+\mu}} \qquad (6)$$

where *r* now denotes the share of opioid fatalities from Rx. As before $\eta < 0$ denotes elasticity of source-conditional demand *H*(), ARC < 0 denotes the arc elasticity of *H* with respect to the two prices, and CROSS > 0 the elasticity of *F* with respect to the Rx price.[70] The final two terms are both positive if $p_R > p_I$ and $m^{1+\mu} > 1$ and either can exceed the first term in magnitude. In particular, even with no price differential, Rx prices can increase total mortality even though it would not increase total opioid consumption. The elasticity formula reduces to the formula used in the main text when $m^{1+\mu} = 1$.

Note that the additional danger of Im opioid consumption (*m* > 1), relative to Rx opioid consumption, is not apparent in the aggregate data. Take the year 2010, prior to the prevalence of fentanyl, in which 13,903 persons died from overdose involving Rx opioids. Because total Rx opioid sales were 247 million MGEs, and many of those were not abused (or even consumed), there were at least 56 fatal Rx overdoses per million Rx MGEs consumed, and probably closer to 100 fatalities per million MGEs. During the same year, 2888 overdose deaths involved heroin whereas ONDCP estimates that heroin consumption was 135 million MGEs, or about 21 fatalities per million MGEs consumed. As discussed in connection with Table 4, I believe that ONDCP's demand model exaggerates heroin consumption, but even my rescaled-NSDUH method puts heroin fatalities at 87 per million MGEs consumed in 2010.

Between 2010 and 2016, fatalities involving Im opioids increased sharply as fentanyl came into the market, but so did Im opioid consumption. ONDCP estimates that heroin consumption increased 74 percent during that time. In addition, the heroin was increasingly sold with fentanyl, which has a much greater MGE content. By CEA's method of assessing shares of heroin versus fentanyl, the increase in Im MGEs consumed was 206 percent between 2010 and 2016. The increase in fatalities involving Im opioids was 390 percent during that period, which is consistent with an increase in deaths per MGE by a factor of 1.6.

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[70] The definition of ARC is $\frac{1-H(p_R)/H(p_I)}{1-p_R/p_I} < 0$.

X. Appendix III: Identifying Federal Opioid Policies

I identified Federal opioid policies for potential analysis by searching the Federal Register for the years 2001-19 for final rules from the Department of Health and Human Services (HHS), the Department of Justice (DOJ), the Department of Labor (DOL), the Department of Transportation (DOT), the Department of Treasury, and the Department of Veterans Affairs containing the word "opioids."[71] Because the DOJ often uses discretion (i.e., case-specific facts and circumstances) rather than the rulemaking process, I also searched DOJ press releases describing department initiatives with the word "drug" and relating to prosecution and sentencing. In reviewing the results, I followed and reviewed sources cited as requiring rulemaking, the most significant of which were the 2010 Affordable Care Act and the Medicare Modernization Act of 2003. I also reviewed relevant prior rulemaking cited by the rules identified in the search.

A number of the DOJ press releases refer to sentencing of, or judgments against, specific companies, gang members, and international drug smugglers. Since 2017, some of the press releases also refer to new procedures for immigration enforcement. The aggregate of these may be significant, but I left that topic for future research except to the extent that it is reflected in the Federal prison population.

I judged a number of final rules to be too insignificant for aggregate analysis, but list them here for completeness. Treasury issued rules, such as 77 FR 64663 (2012), that exclude opioids from the medicine exemption from the Iranian sanctions. DOL and DOT issued rules regarding the possession of opioids on the job for specific occupations. HHS issued rules in 2017, 2018, and 2019, respectively, requiring confidentiality of substance abuse disorder patient records (82 FR 6052), requiring Accountable Care Organizations to monitor opioid utilization (83 FR 67816), and providing guidelines for Federal workplace drug testing programs (84 FR 57554). A 2002 rule from the Drug Enforcement Administration (DEA, which is part of the DOJ) moved the semisynthetic opioid buprenorphine from Schedule V to Schedule III, which is

[71] A rule was excluded if "opioids" were mentioned only as part of a summary of public comments rather than the agency's own description of its rule.

more restrictive (67 FR 62354). A 2012 DEA rule (79 FR 37623) placed the opioid Tramadol onto Schedule IV. Tramadol is one-tenth as potent that morphine and one-fifteenth oxycodone.

Table 1. Point Elasticity Estimates from Aggregate Price and Share Data

Data		2009-11	2013	2014	2015	2016	2017
Marginal Rx price, $2016 per MGE		82.7	101.0	111.7	130.4	144.1	*144.1*
Marginal Im price, $2016 per MGE		111.3	96.5	95.2	68.5	66.3	47.4
Rx share of overdoses		0.726	0.569	0.495	0.418	0.331	0.266
Elasticity	Calibrated within-source elasticity		2013	2014	2015	2016	2017
A. Total wrt Rx price	-0.25		-0.1	-0.1	0.0	0.0	0.1
	-0.50		-0.3	-0.2	-0.1	0.0	0.1
	-1.00		-0.6	-0.4	-0.3	-0.1	0.1
	-1.50		-0.8	-0.7	-0.7	-0.4	-0.2
B. Total wrt Rx price, at twice avg. Rx	-0.25		-0.1	0.0	0.0	0.1	0.2
	-0.50		-0.2	-0.1	0.0	0.1	0.3
	-1.00		-0.4	-0.3	-0.2	0.0	0.4
	-1.50		-0.8	-0.6	-0.7	-0.4	-0.2
C. Total wrt Im price	-0.25		-0.1	-0.1	-0.2	-0.2	-0.2
	-0.50		-0.2	-0.3	-0.3	-0.4	-0.4
	-1.00		-0.4	-0.5	-0.6	-0.7	-0.8
	-1.50		-0.7	-0.8	-0.9	-1.0	-1.1
D. Rx "multiplier"	-0.25		0.1	0.0	-0.2	-0.3	-0.6
	-0.50		0.1	0.1	-0.4	-0.6	-1.3
	-1.00		0.3	0.2	-0.6	-1.0	-2.7
	-1.50		0.4	0.3	-0.4	-1.0	-3.3
E. Im wrt Rx price	-0.25		0.9	1.0	0.7	0.8	0.8
	-0.50		0.8	0.8	0.6	0.7	0.9
	-1.00		0.5	0.6	0.3	0.6	0.8
	-1.50		0.2	0.3	-0.2	0.2	0.3

Notes:
2017 Rx prices are assumed to be the same as 2016.
The "Rx multiplier" is change in total overdoses for each price-induced change in Rx overdoses,. based on actual price changes.

Table 2. Changes in Federal incentives related to the market for opioids

	Incentives for:		
Year	Prescribers	Patient Rx purchases	Illicit Manafucture and Distribution
2000	VHA mandates "5th Vital Sign"[a]		
2001	Pain management becomes part of Medicare/Medicaid accreditation (CMS delegated to TJC)[b]		
2005	DEA clarifies that opioid refills are not permitted, but that subsequent prescriptions can be obtained without appointment.[c]		
2006		Medicare Part D begins covering opioids, but not benzos (CMS)[d]	Fentanyl manuf. shutdown; DEA prohibitions follow.[e]
2007	DEA allows multiple prescriptions with a single office visit.[f] CMS publicizes & requires quality measures, including HCAHPS pain questions, for full reimb.[g]		
2010	DEA allows electonic Rx.[h]		First DEA Rx take-back programs.[i]
2011		Product reformulation and withdrawal (FDA)[j]	*
2012	CMS penalizes low HCAHPS scores.[k]		*
2013	VHA Opioid Safety Initiative; peak VHA opioid Rx[l]	Medicare Part D begins covering benzos too (CMS).[m]	Holder memo: DOJ does not prosecute nonviolent drug crimes[n]
2014	DEA switches Hydrocodone combination products from Schedule III to Schedule II.[o]	Medicaid expansion; deadline for other insurance to cover benzos. (ACA)[p]	*
2016	CARA Act	CARA Act	*
2017	CMS changes its use of pain management surveys.[q]	FDA first requires benzos to carry an opioid-interaction warning.[r]	Holder memo reversed.[s]
2018	Rx quotas tightened.[t]	SUPPORT Act	*; SUPPORT Act
2019	CMS removes pain management questions from HCAHPS[u]		*; Series of new DEA prohibitions.[v]

Notes:

[a]Department of Veteran Affairs (2000)
[b]Joint Commission on Accreditation of Healthcare Organizations Pain Standards for 2001. See also 66 FR 4076.
[c]DEA. Clarification of Existing Requirements Under the Controlled Substances Act for Prescribing Schedule II Controlled Substances. August 2005.
[d]70 FR 4228 (January 2005).
[e]DEA prohibits chemicals used to manufacturer fentanyl in 2008 (73 FR 43355) and 2010 (75 FR 37295).
[f]DEA. Issuance of Multiple Prescriptions for Schedule II Controlled Substances. Nov 2007.
[g]71 FR 68193 (November 2006).
[h]DEA. 75 FR 61613 (October 2010)
[i]DEA. "DEA Heads First-ever Nationwide Prescription Drug Take-back Day."
[j]https://www.medpagetoday.com/productalert/devicesandvaccines/19409 and https://www.fda.gov/drugs/drug-safety-and-availability/fda-drug-safety-communication-fda-
[k]CMS. Medicare Program; Hospital Inpatient Value-Based Purchasing Program
[l]Good (2018).
[m]77 FR 22076 (April 2012).
[n]Holder, Eric. "Department Policy on Charging Mandatory Minimum Sentences and Recidivist Enhancements in Certain Drug Cases."
[o]DEA. Schedules of Controlled Substances: Rescheduling Hydrocodone Combination Products from Schedule III to Schedule II. August 2014.
[p]Benzo coverage is in Section 2502 of the Patient Protection and Affordable Care Act.
[q]Effective Oct 2017, the pain part of HCAHPS would no longer be used for VBP, although still for accreditation (81 FR 79571). Effective Oct 2019, outpatient departments would participate in their version of HCAHPS (OAS CAHPS; 71 FR 79771).
[r]https://www.fda.gov/drugs/information-drug-class/new-safety-measures-announced-opioid-ana
[s]Sessions, Jeff. "Department Charging and Sentencing Policy."
[t]83 FR 32784 (July 2012).
[u]CMS. "HCAHPS Update Training" (February 2019).
[v]Spanning 5/2016 through 11/2019, 10 DEA rules put various fentanyl analogs on Schedule I.
*see also competition from Rx

Table 3. Six Federal wedges in opioid supply chains

Billions of dollars per year

Federal law enforcement, 2016	
1.3	Reduced inmate opportunity costs, estimated as 16 hours per day valued at the Federal mininum wage, of reducing Federal incarceration by 30,000 persons.
1.3	Reduced avoidance costs of suppliers who avoid incarceration (assumed equal to inmate opportunity costs).
2.5	Total costs removed from illicit supply chains.
2.0	Total costs removed from illicit opioid supply chains.
Hospital Accreditation/Certification, 2016	
242.0	Total Medicare spending on hospitals
4.8	2 percent of that spending, per DRA of 2005
0.7	Pain management share of the 2%, estimated as pain management share of HCAHPS questions.
Permitting "Refills", 2016	
1.3	Out of pocket spending on Rx opioids.
0.5	Out of pocket spending by those getting refills
0.2	Convenience value inferred from adherence patterns
Medicare Part D opioid abuse subsidies, 2016	
4.0	Expenditure on Part D opioid Rx.
1.2	Part D abuse subsidy, estimated with the share of Part D's gross drug costs reimbursed by Part D plans and the share of Rx that is abused.
Medicare Part D benzo subsidies, 2016	
0.5	Opioid abuse subsidy, rescaled by (i) the propensity that an opioid overdose involves benzos, (ii) the relative Walmart price for the smallest size of each prescription reported at truemedcost.com, and (iii) the share of opioid-benzo fatalities that involve Rx.
Medicaid opioid abuse subsidies, 2016 increase from 2013	
0.1	Additional Medicaid claims for abused opioid Rx, net of 17% rebate.
Combination of increasing all the above subsidies or reducing the above penalties.	
4.7	Combined

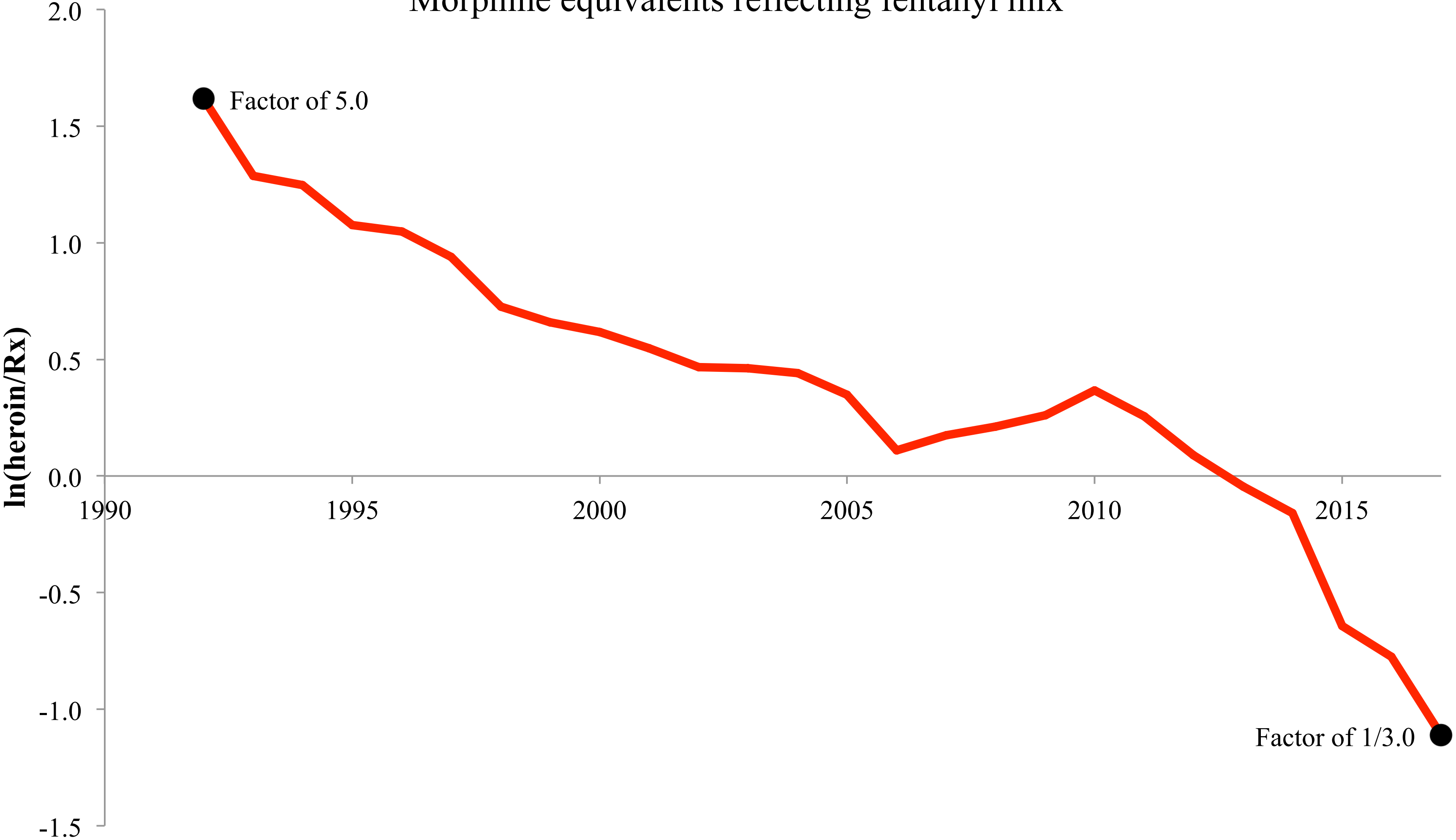
Table 4. Estimates of Consumption and Expenditure on Im Opioids, 2013

Source	Assume	Estimate type	Im MGEs, millions	Im expenditure, $ billions All	31%
ONDCP	ONDCP demand method	Lower bbd.	95	8.9	2.8
ONDCP	ONDCP supply method	Point est.	132	12.4	3.9
NSDUH days	66% undercount and each day costs $30	Point est.	71	6.7	2.1
Rx sales	Per MGE, Rx abuse and Im consumption are equally fatal. Rx abuse is 35% of Rx.	Point est.	60	5.6	1.8
Rx sales	Per MGE, Rx abuse is no more fatal than Im consumption	Upper bnd.	172	16.1	5.0

Notes: MGEs and expenditure are converted at $94 per MGE (Table 1).
31% of expenditure is the savings from purchasing 2013 Im quantities at 2016 prices.
The ONDCP demand method assumes a particularly large underreporting factor.

Figure 1. Retail Prices: Heroin Relative to Rx Opioids

Morphine equivalents reflecting fentanyl mix



Sources: UN, DEA, FDA, CEA.
Note: 2011 Rx prices are 29-71 generic vs branded, reflecting their shares in aggregate Rx opioid quantity reductions 2011-15. Rx prices obtained from the secondary market (higher) or net of third-party payment (lower) are not reflected in this series.

Figure 2. Consumption responses when Im marginal prices are low

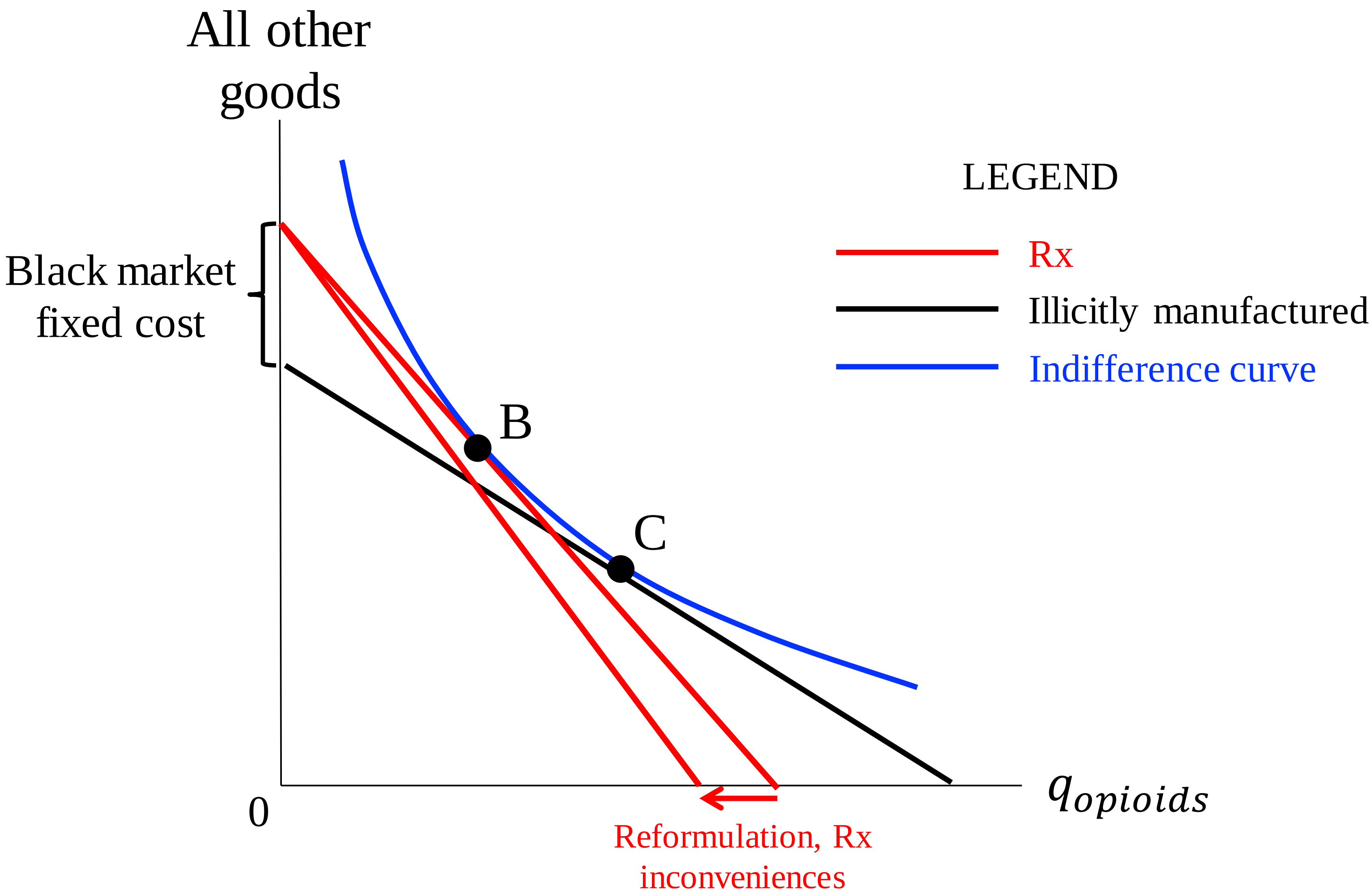


Figure 3. Out-of-Pocket Opioid Prices by Source, circa 2015

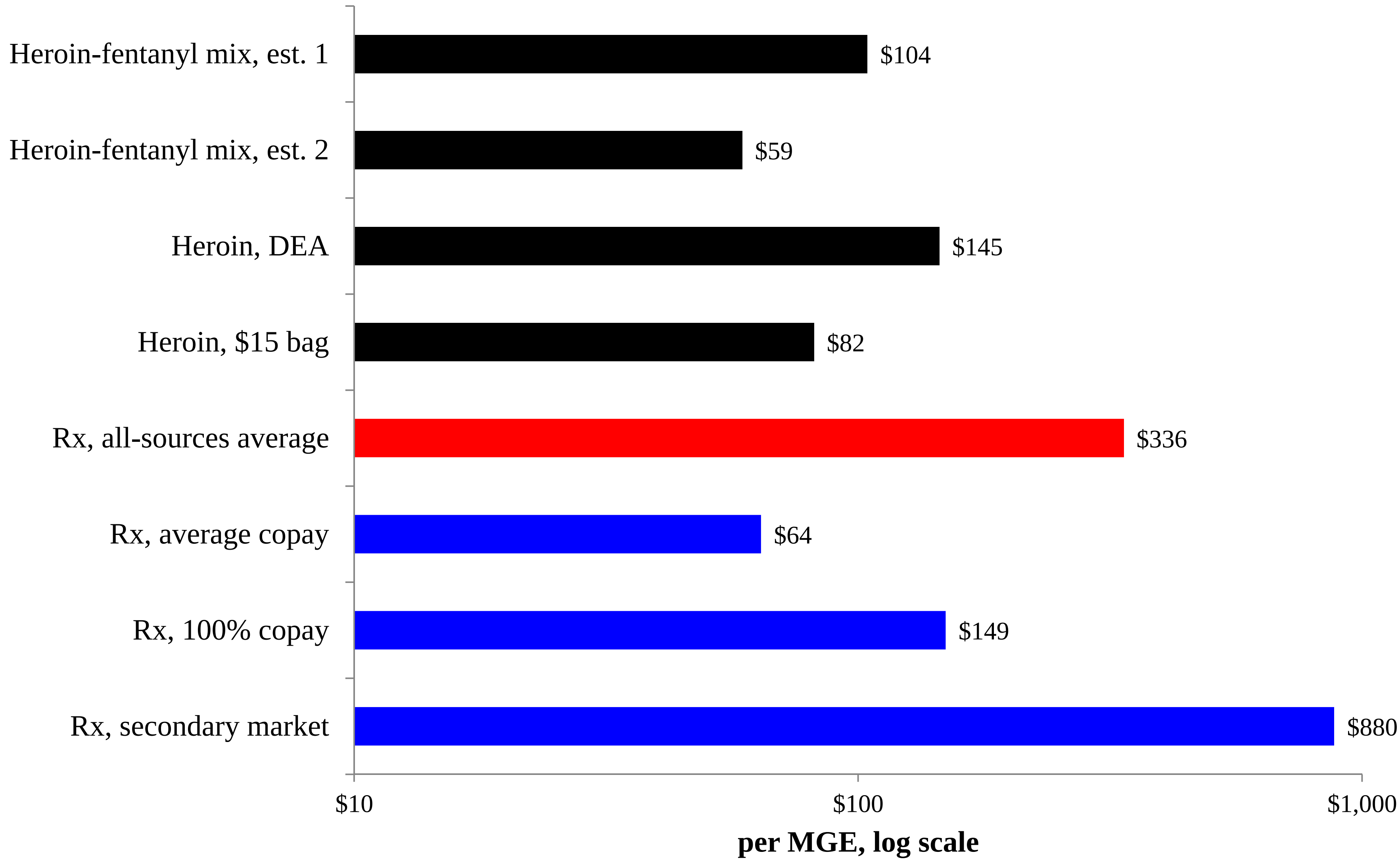


Figure 4. Consumption responses when Im marginal prices are high

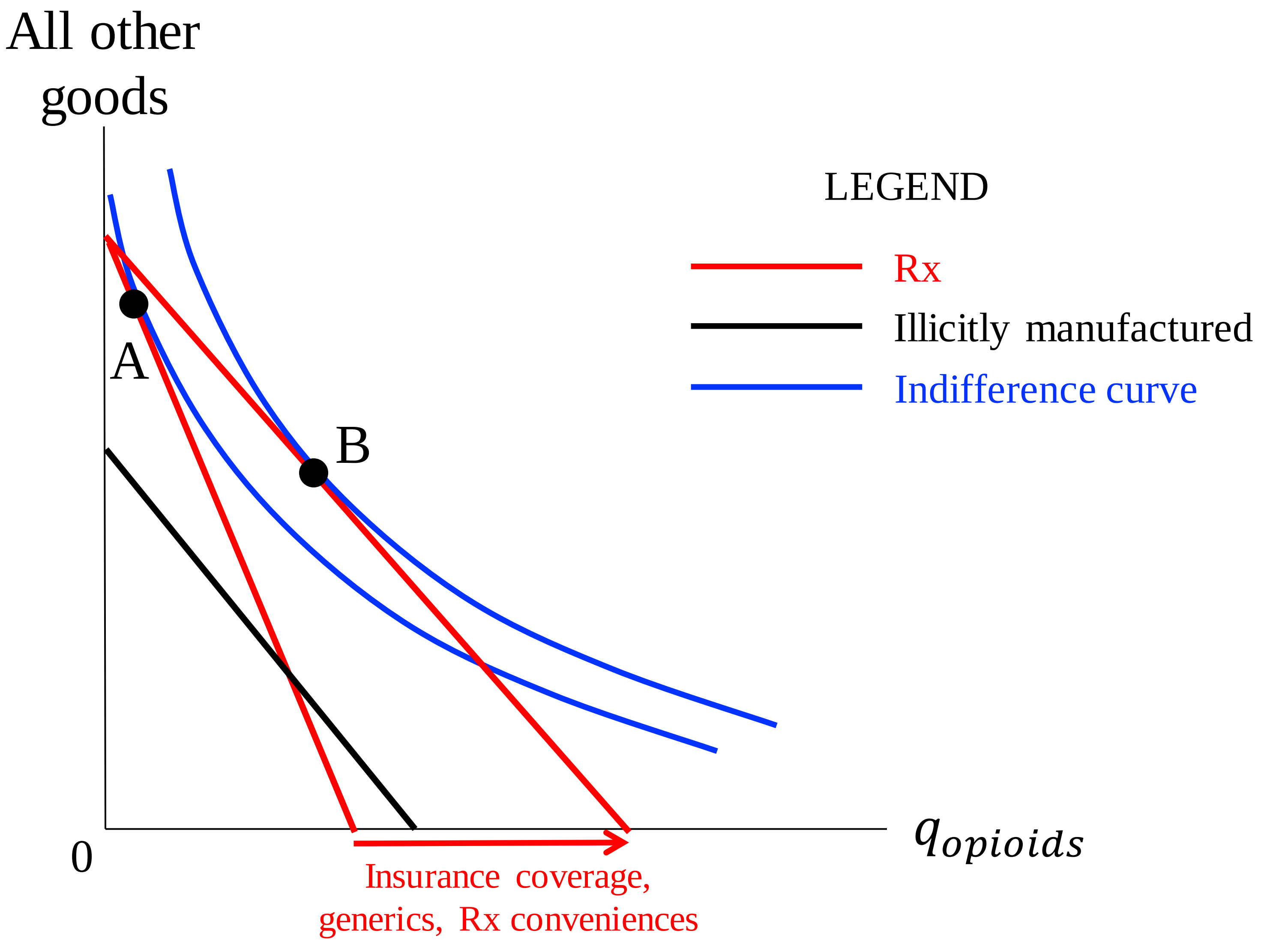
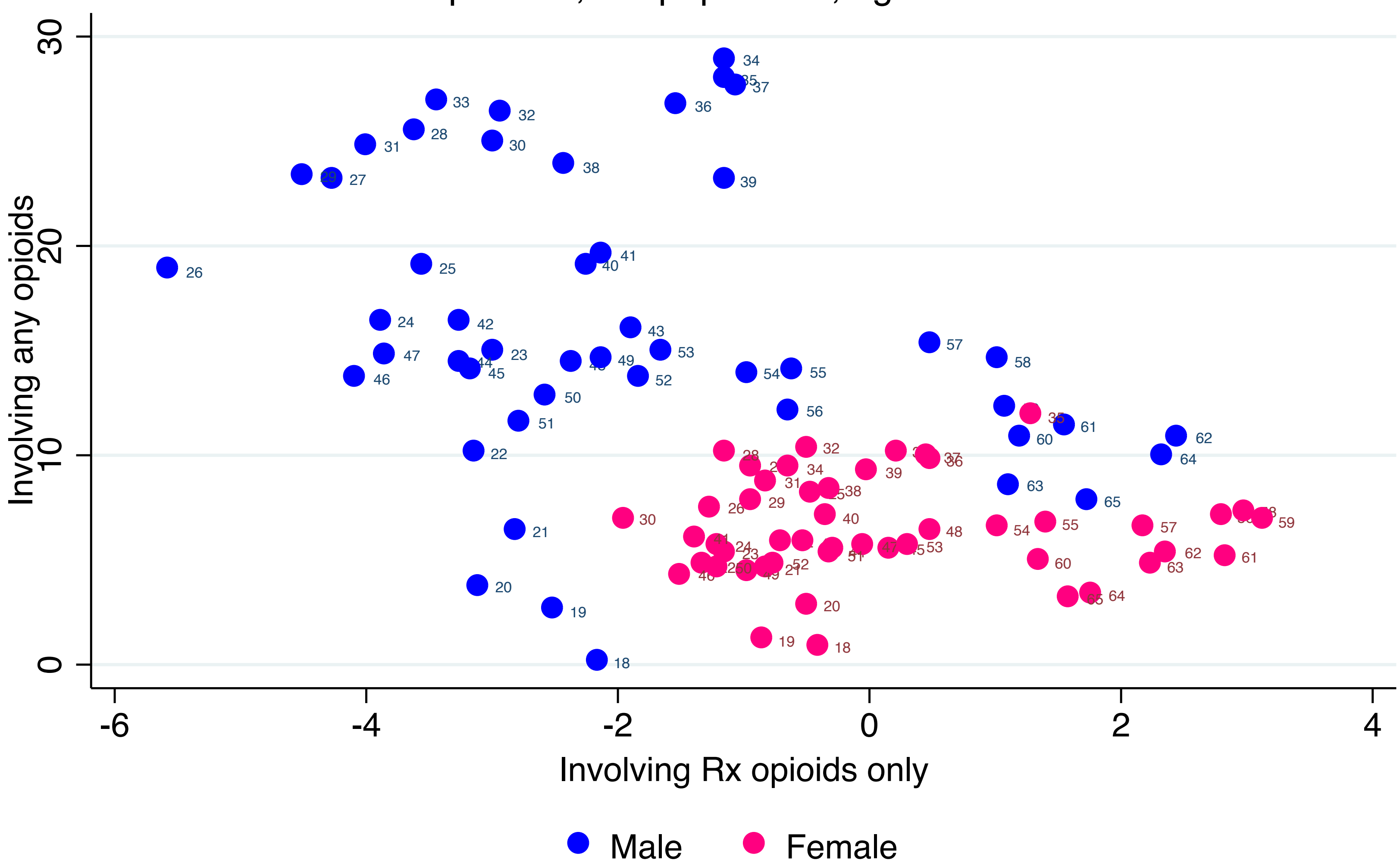


Figure 5. Overdose death rate changes 2009-10 to 2016-17

per 100,000 population, ages 18-65



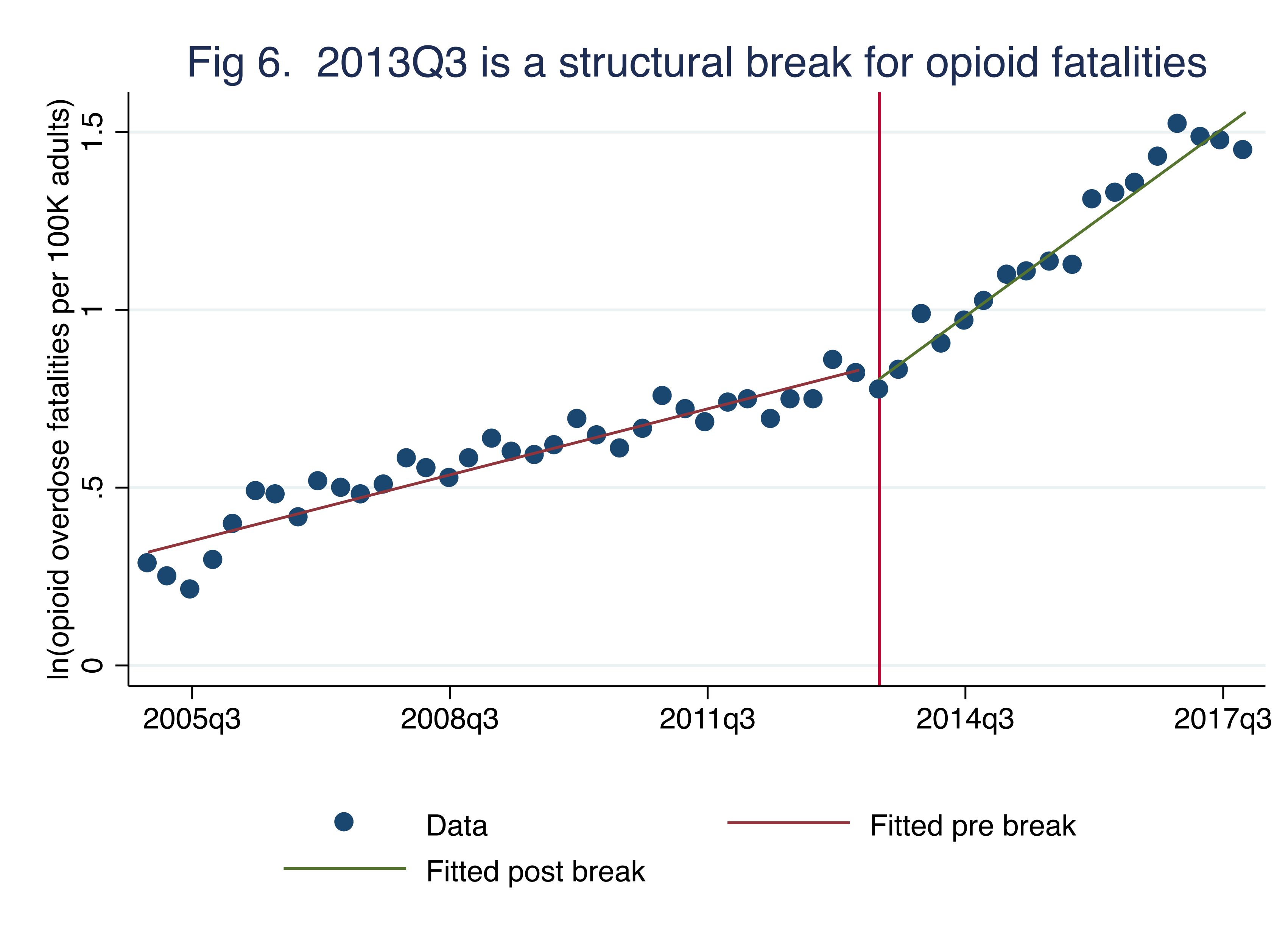
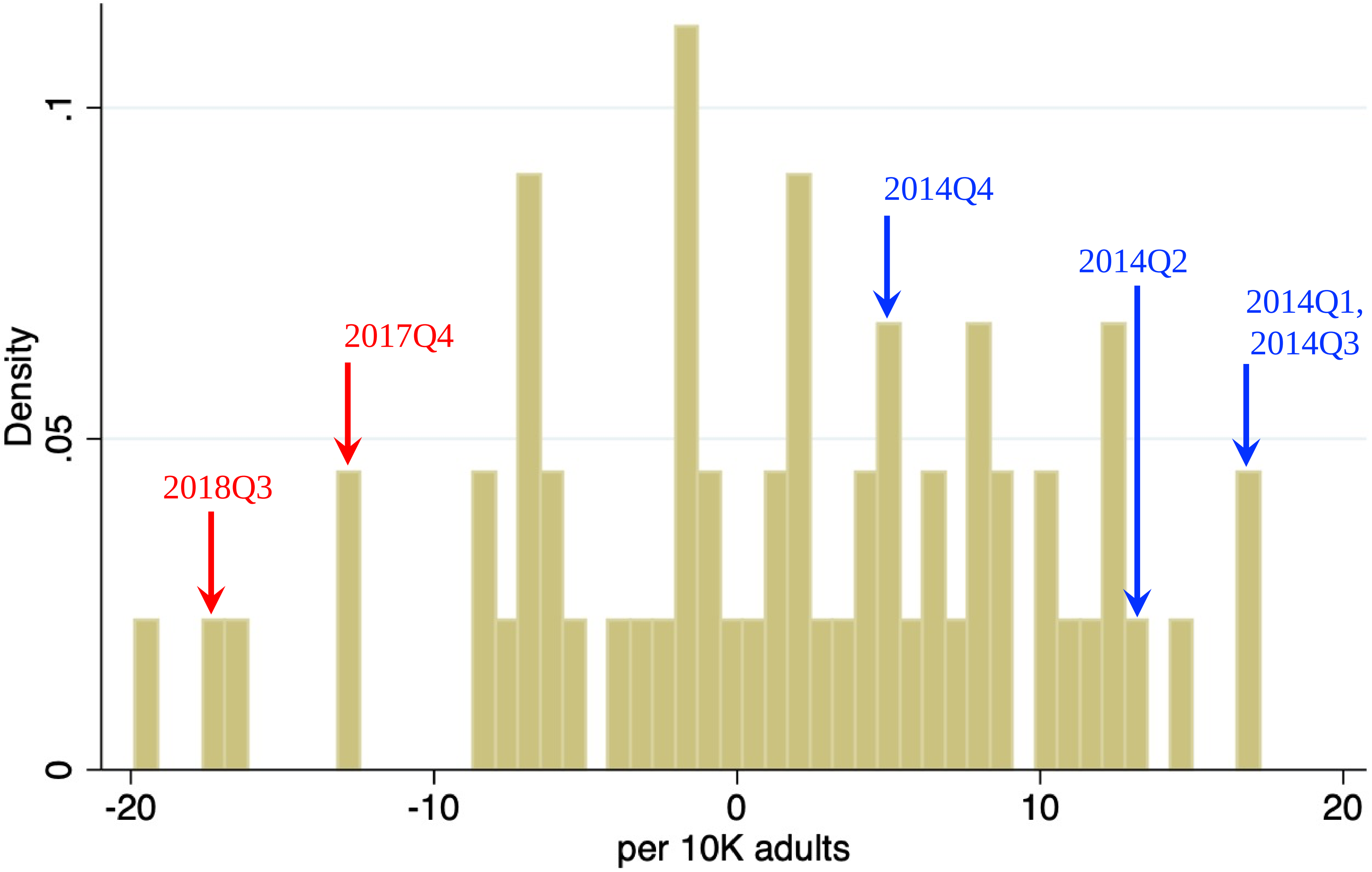


Fig 6. 2013Q3 is a structural break for opioid fatalities
ln(opioid overdose fatalities per 100K adults)
0
.5
1
1.5
2005q3
2008q3
2011q3
2014q3
2017q3
Data
Fitted pre break
Fitted post break

Figure 7. YOY change in recent heroin usage



Source: NSDUH ages 16+. 2014-15 changes not shown due to survey redesign.

Figure 8. Predicting the "choices" of an irrational consumer

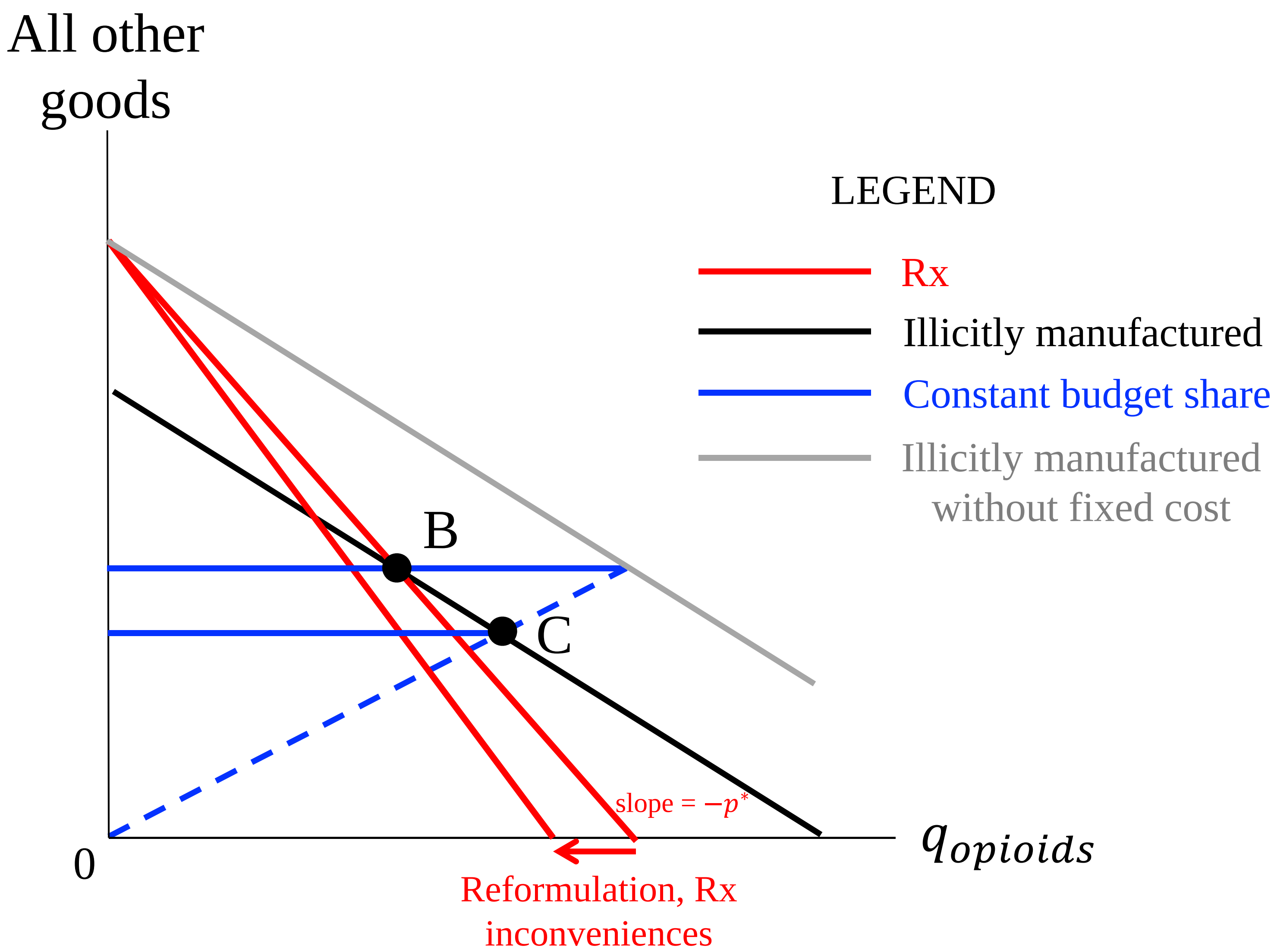
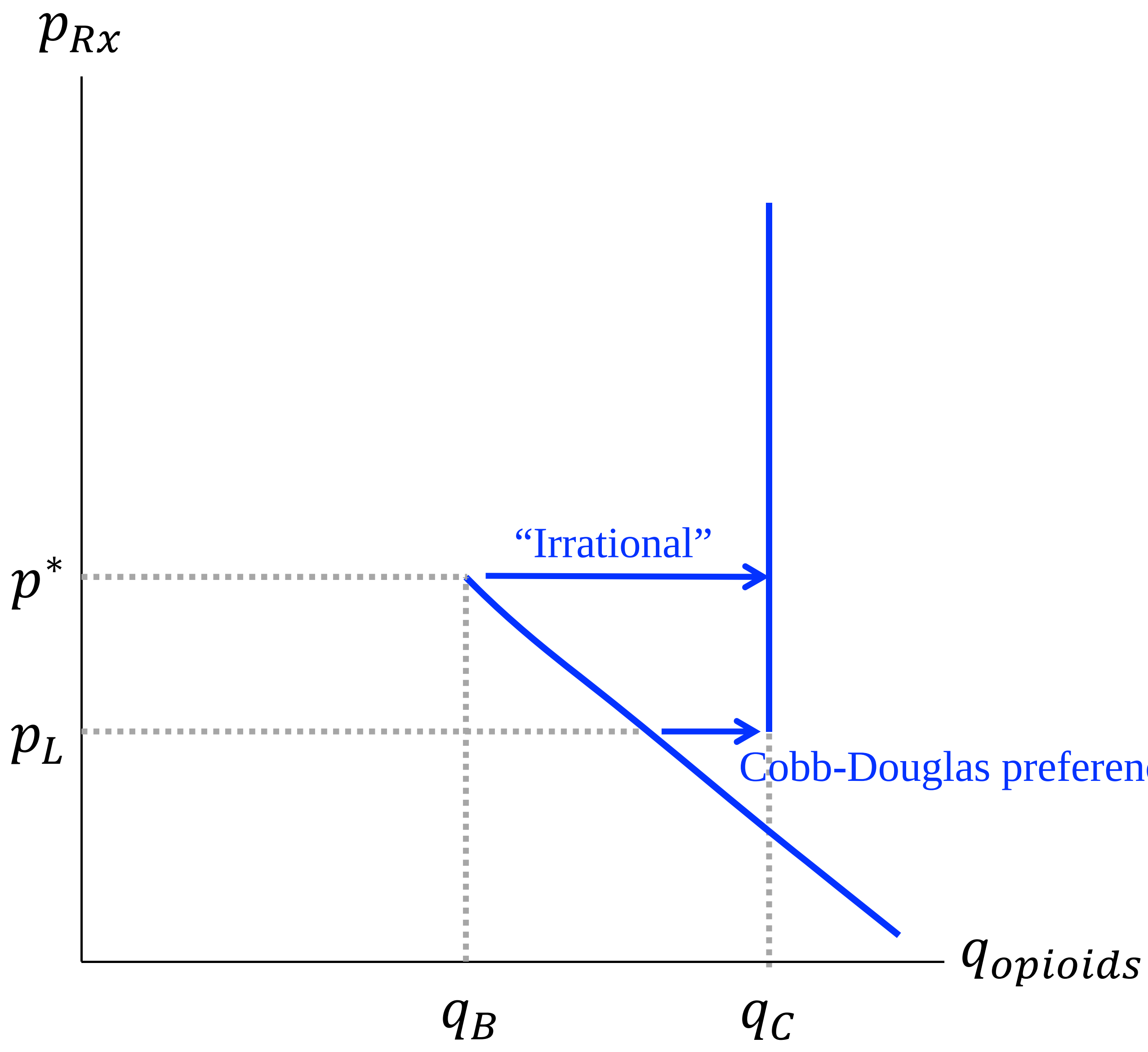


Figure 9. Rational and irrational demand curves as a function of the Rx price.

(Price and quantity are shown on log scales)



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