Bunching in the Hong Kong Housing Market*

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Abstract: In Hong Kong the buyer of a property is obligated to pay a stamp duty (SD). The amount of tax depends on the transaction price, and the amount to pay can be almost nothing to as high as 3.75% in our sample. The progressive and nonlinear transaction SD schedule has also gone through several changes, with cutoff prices or tax rates modified. First, we document the amount of "bunching" at various cutoff prices, and show that bunching follows the changes in the SD schedule closely. Second, we look further into characteristics of the properties that bunch at the cutoff points. We fit a hedonic regression on the data, and we find some weak evidence of underpricing where a cutoff price is introduced.

JEL codes: H26, R21

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1. Introduction

This paper studies how a nonlinear tax schedule affects property sellers' and buyers' behavior. In Hong Kong, upon the sale of a property, a stamp duty (SD) is imposed on the buyer. The rate goes from near-zero to above 3%, and the schedule is highly nonlinear (See Table 1). For example, between February 2007 and March 2010, a property sold at the price below $2 million may be subject to a SD of $200 but if the property is sold at $2.1 million the SD would go up to $10,100. The SD schedule creates an incentive for "bunching": buyers and sellers tend to transact at or just below the cut-off price to avoid the tax if the market price of the property is only slightly above the cut-off price. Using the same example, we should observe a lot of transactions at $2 million but relatively fewer at prices slightly above $2 million.

But clustering at the cut-off prices can be due to other reasons. For convenience, most transactions occur at prices of round numbers, e.g., $1 million, $2 million, etc. Finding transactions around the cut-off points does not imply that those transactions are induced by the SD schedule. To identify bunching, we make use of the two major changes in the SD schedules, one in 1997 and one in 2007. If the tax changes are exogenous, we can observe how bunching changes with the SD schedule.

Next we study the nature of the bunching transactions by fitting a hedonic model to the data. We subtract the hedonic price from the actual transaction price of each property to obtain a measure of the unit's mispricing, and we study how the mispricing changes with the SD schedule.

Tax avoidance has been studied by economists. Feldstein (1999) shows, both theoretically and empirically, that the deadweight loss of the income tax would be much higher when tax avoidance is taken into account. Kleven *et.al.* (2011) conduct a tax enforcement field experiment in Denmark and show that prior audits and threat-of-audit letters can deter tax avoidance.

There are a few studies that have documented evidence of bunching at kink points created by nonlinear income tax schedule. Burtless and Moffitt (1984) and Friedberg (2000) use the Current Population Survey data to document bunching of elderly individuals receiving Social Security benefits but still working and are subject to the Social Security earnings test. Saez (2010) uses US tax return data to document bunching behavior of self-employed individuals around the first kink point of the Earned Income Tax Credit. Chetty et. al. (2011) present evidence of bunching at kink points in using Danish tax records.

Several research studies the effect of kink points in situations other than income tax schedule. Blundell and Hoynes (2004) find evidence that individuals likely to be eligible for the UK family credit, which has a 16 hour minimum working requirement, bunch at exactly 16 hours a week. Ito (2012) studies the effect of nonlinear pricing in the electricity market and find strong evidence that consumers respond to average price instead of marginal price.

There are studies of the effects of nonlinear SD schedule on the housing market. Best and Kleven (2013) exploit the anticipated and unanticipated changes in the nonlinear SD schedule in Britain and show that the effect of SD on house prices is large (200-500% of the tax itself). Kopczuk and Munroe (2012) study the impact of the 1% "mansion tax" imposed on properties transacted in New York at prices above $1million. They provide evidence of bunching of transactions at $1 million and show that the incidence of this tax falls on sellers and may exceed 100% of the tax itself.

2. Description of the Data and the Hong Kong Housing Market

We use property transaction data provided by the Economic Property Research Center (EPRC) as our main source of data. The dataset includes most of the property transactions from 1996 to 2007. It contains various aspects of each transaction, including prices[1], gross and net area[2], address, floor, age, and number of bedrooms and living rooms.

The 12 years of data originally contain 2,059,405 transactions. First, we drop 402,961 observations of having a zero or negative age. These are either new properties or transactions involving units that are not yet completed. Because the first-hand property market is highly oligopolistic in Hong Kong, we do not want to include those transactions in our analysis. Second, there are various types of transactions in the EPRC data such as change of owner's name,

[1] Unless otherwise indicated, all prices ($) are in current Hong Kong Dollar.

[2] In Hong Kong, gross area of a property includes the area of the common space of the housing estate such as parking space. And net area, broadly defined, is the area of the housing unit itself.

provisional agreement and others. We only want to keep the final agreement of each transaction and hence we drop 858,245 observations to keep only the assignment type of contract. Third, we drop 19,271 transactions for involving only adding or dropping some names of owners. Most of those transactions are due to change of owners (e.g., parents giving the property to children) and we do not consider them in our analysis. Fourth, we drop 234,744 observations due to missing age, floor, gross area, net area and bay window area, or that the property is new or not yet available in the market. Fifth, we drop 12,092 observations for having a zero or negative price. Finally, we drop the top and bottom 2% of the observations according to the real price (deflated by the composite CPI, at May 2005 value) per squared-feet. The above procedures leave us with a total of 493,054 observations.

3. Stamp Duty in Hong Kong

During our sample period (1996 to 2007), the Hong Kong government modified the SD schedule three times. The first modification happened in April 1997, the second one in April 1999, and the last one in March 2007. Since the second change only involves adding $6 million as a new cutoff price and we have very few observations near that price range, we only consider the first and third changes.

The two modifications were announced in the annual Budget Speech by the Financial Secretary in March 12th 1997 and February 28th 2007 respectively, and then they are implemented within a month after the announcements. We use a news-search software, WiseNews,[3] to make keyword searches around the time of the announcements and find no related news prior to the announcements in the Budget Speech. We are therefore confident that the announcements were unexpected.

Table 1a shows the SD schedule before and after the change in Apr 1997. The modification only involves moving the cutoff prices up: $0.75 million to $1 million, $1.5 million to $2 million, $2.5 million to $3 million and $3.5 million to $4 million. The tax rates are kept constant. Figure 1a plots the SD schedules (the transaction tax as a percentage of the

[3] See the Hong Kong news database at http://wisenews.wisers.net.

transaction price) before and after this change. The SD schedule simply moves to the right, shifting all the cutoff prices up.

Table 1b shows the SD schedule before and after the change in March 2007.[4] This change mostly involves removing \$1 million as a cutoff price, and making all transactions at or below \$2 million paying essentially no tax (\$100). All other rates are kept constant. Figure 1b plots the SD schedules before and after this change.

Notice that unlike the two similar cases in the UK (Best and Kleven, 2013) and in New York and New Jersey (Wojciech and Munroe, 2012), the property transaction tax system in Hong Kong does not feature discrete jumps at the cutoff prices. For example, under the current system in the UK, the proportional tax rate jumps from 1% to 3% at a price of £250,000, so that the SD for a house transacted at £249,000 would be £2,490 while the SD for a house transacted at £250,000 would be £7,500. In contrast, the increase in SD at cutoff prices is gradual in Hong Kong. For example, under the tax system implemented since March 2007, a house transacted at a price of \$3 million is subject to a SD of \$45,000 (1.5%) while a house transacted at \$3.1 million is subject to a SD of \$55,000 (1.83%). Because the jumps of SD at cutoff prices are more gradual in Hong Kong, there should be less incentive to bunch around the cutoff prices.

4. Evidence of Bunching in Hong Kong

As in Best and Kleven (2013), we follow Chetty *et al*. (2011) and Kleven and Waseem (2013) to estimate the amount of bunching at the cutoff prices. We fit a flexible polynomial to the empirical distribution of transactions to estimate the counterfactual distribution of transaction without bunching. In particular, we group transactions into price bins of \$10,000 and estimate the following equation for each cutoff price $\bar{h}_v$:

$$n_i = \sum_{p=0}^{5} \beta_p (d_i)^p + \sum_{r \in R} \eta_r I\left\{\frac{\bar{h}_v + d_i}{r} \in \mathbb{N}\right\} + \sum_{k=\bar{h}_v-2}^{\bar{h}_v+2} \gamma_k I\{i = k\} + \mu_i \qquad (1)$$

[4] The actual change occurred after 10:59 am on February 28, 2007. Since the number of observations on that day is small relative to the whole sample and we do not observe the exact time of transaction, we assume the change to be in effect from March 2007.

where n_i is the number of transactions at price bin i, d_i is the distance of price bin i from the cutoff price $\bar{h}_v$, R is the set round numbers of \$50,000 and \$100,000 and lucky numbers of \$80,000, and $\mathbb{N}$ is the set of natural numbers. The first term of (1) is a fifth-order polynomial as a function of the distance from the cutoff price. The second term contains the fixed effects of round numbers and lucky numbers. The third term picks up the fixed effects near the cutoff price (plus and minus \$20,000). The counterfactual distribution $\hat{n}_i$ is simply the fitted version of (1) without the third component.

To measure the amount of distortion near the cutoff price, we use the estimated equation (1) and calculate: a) bunching b as the sum of the three γ's at and below the cutoff price, normalized by the counterfactual density in the same region, and b) missing m as the sum of the two γ's above the cutoff price, normalized by the counterfactual density in the same region. That is,

$$b = \frac{\sum_{k=\bar{h}_v-2}^{\bar{h}_v} \gamma_k}{\sum_{k=\bar{h}_v-2}^{\bar{h}_v} \hat{n}_k}, \qquad m = \frac{\sum_{k=\bar{h}_v+1}^{\bar{h}_v+2} \gamma_k}{\sum_{k=\bar{h}_v+1}^{\bar{h}_v+2} \hat{n}_k} \tag{2}$$

The magnitude of b tells us the amount of bunching as a proportion of the counterfactual number of transaction. For example, $b = 1$ means that the number of bunching transactions is 2,000 if the counterfactual number is 1,000. A larger number means more bunching. The magnitude of m has a similar interpretation, but we expect the sign of it to be negative. Equation (1) is estimated by nonlinear least squares with bootstrapped standard errors (2000 times). The standard errors for b and m are calculated by the delta method.

Figure 2 shows the actual and counterfactual distributions for the four different cutoff prices (\$0.75 million, \$1.5 million, \$2.5 million, and \$3.5 million) over the period Apr 1996-Mar 1997. As the figure suggests, there are significant amount of bunching at the cutoff prices. There is also more bunching at lower cutoff prices ($b_{750k} = 0.892, b_{1.5m} = 0.46, b_{2.5m} = 0.259, b_{3.5m} = 0.331$). The estimates of the missing mass, m, are negative as expected.

Figure 3 shows the two distributions for four different cutoff prices ($1 million, $2 million, $3 million, and $4 million) after the first modification of the stamp duty. It covers the period between Apr 1997 and Feb 2007. There is significant amount of bunching at the cutoff prices, and the amount of bunching decreases with the magnitude of the cutoff prices ($b_{1m} = 0.436, b_{2m} = 0.197, b_{3m} = 0.188, b_{4m} = 265$). The estimates of the missing mass, m, are negative as expected.

Figure 4 shows the two distributions for three different cutoff prices ($2 million, $3 million, and $4 million) after the second modification of the stamp duty. It covers the period between Mar 2007 and Dec 2007. There is again significant amount of bunching at the cutoff prices, and the amount of bunching is the highest at the lowest cutoff price ($b_{2m} = 0.477, b_{3m} = 0.171, b_{4m} = 294$). The estimates of the missing mass, m, are also negative as expected.

Figures 2-4 can only capture the snapshots of the bunching during periods when the cutoff prices are stable. We make use of the two modifications of the SD in Apr 1997 and Mar 2007 to illustrate the dynamic responses at the old and new cutoff prices. In particular, the removal of a cutoff price would eliminate bunching in the neighborhood of that cutoff price, while the addition of a new cutoff price would induce bunching in the neighborhood of that cutoff price. Figures 5-6 show the dynamic responses.

Figures 5-6 compare the bunching behavior before and after the first SD modification in Apr 1997. To remove the seasonal effect, we compare the distributions for the periods Apr 1996-Mar 1997 and Apr 1997-Mar 1998. Under this modification, the first cutoff price shifted from $0.75 million to $1 million. As seen in Figure 5, the bunching around $0.75 million disappears after Apr 1997. The estimate of b changes from positive to negative (both statistically insignificant). In contrast, Figure 6 shows that bunching emerges around $1 million after Apr 1997. The estimate of b changes from negative to positive (both statistically significant). Similar pattern happens at other cutoff points but are not reported here.

Figures 7-8 compare the bunching behavior before and after the second SD modification in Mar 2007. We compare the distributions for the periods Mar 2006-Dec 2006 and Mar 2007-Dec 2007 to remove the seasonal effect. This modification removes the lowest cutoff price at $1 million. As seen in Figure 7, the bunching around $1 million decreases, with the estimate of b

drops from 0.61 to 0.219 after Mar 2007. The modification also reduces the SD to $100 for all transactions at or below $2 million, making this cutoff price more "attractive" to bunching behavior. Figure 8 shows that it is indeed the case, with the estimate of b goes up from 0.177 to 0.477 after Mar 2007.

5. Controlling for Housing Characteristics

Unlike Best and Kleven (2013) and Wojciech and Munroe (2012), our data contain the attributes of the properties transacted. We make use of this additional feature in our data to evaluate the effect of modifications of SD on unobserved qualities of properties around cutoff prices.

We first estimate a hedonic regression for the sample from March 1996 to December 2007. The first two months of 1996 are dropped as the SD schedule that ended in March 1997 only began in March 1996. Log housing price (deflated by composite CPI, at May 2005 value) is used for the hedonic regression, and the explanatory variables include floor, age and its squared, gross area and its squared, net-gross area ratio and its squared, dummy for clubhouse, bay window size, dummy for swimming pool, and 59 district dummies. We fit the hedonic regression for each month separately, and the average adjusted R^2 is around 0.9. The coefficient estimates all have the correct signs. Adding more explanatory variables or more interaction terms in the regression can improve the fit further, but the results we present below are robust to changes in the specification.

Since the goal here is to find if the nonlinear SD schedules affect property prices near the cut-off prices, we drop observations that are at, $0.01 million below or $0.02 million below the cutoff prices from the hedonic regression, depending on the SD schedule in effect. For example, from March 2007 till the end of the sample we drop observations at or within $0.02 million below $2, 3, 4 and 6 million. Since we have over 400,000 observations and observations and the number of observations near the cutoff prices is small, the hedonic regression is not affect much by this procedure.

Based on the hedonic regression, we calculate the residuals for those properties that are at the cutoff points or within $0.02 million below.[5] Assuming that the hedonic regression is

[5] The sample is too small if we only consider housing units that are exactly at the cutoff points. We have also used $0.01 and 0.05 million below the cutoff points for estimation, and find that the results are rather similar.

adequate, the residual should tell us if a property is overpriced or underpriced relative to the hedonic price. For instance, if a property is underpriced at or right below a cutoff price, the residual should be substantially more negative than otherwise would be. We next test if the mean of the residuals is different before and after the two tax changes.

In Table 2a, we regress the residuals on a constant and a dummy for the period covered by the SD schedule in effect from April 1997. The three cutoff prices ($1.5, 2.5 and 3.5 million) are removed by the change in April 1997, but we do not observe any change in the residuals. We do not have sufficient observations for the regression at $0.75 million.

In Table 2b, we look at the cutoff prices ($1, 2, 3 and 4 million) that are introduced by the change in April 1997. We find that the residuals for the first two cutoff prices drop significantly with the change, suggesting those properties are significantly underpriced, relative to the hedonic price. No such drop is found for the other two cutoff prices.

In Table 2c, we look at the period before and after the SD schedule change in March 2007. While the $1 million cutoff price is removed by the change, we do not observe any difference in the residuals. The only change is found for the cutoff price $3 million.

Except for the evidence of underpricing at the cutoff prices of $1 and 2 million under the first SD schedule change, for other cutoff prices we do not find any consistent pattern in the residuals before and after the change in the SD schedule.

6. A Measure of Potential Tax Evasion

While we only find mixed evidence on mispricing near the cutoff prices induced by a change in the tax schedule, we can obtain an alternative measure of the potential amount of transaction tax evasion by summing up the mispricing at or below the cutoff prices. For the residual (mispricing) to be interpretable, we rerun the hedonic regression but with the dependent variable changed to real price, instead of log real price. The fit of the hedonic regression is essentially the same as the one in log.

Once again, we only consider prices at the cutoff up to $20,000 below. As a comparison we also calculate the sum of residuals at prices not near the cutoff. For example, during most of the sample when $1, $2, $3 and $4 million are the cutoff prices, we also calculate the sum of residuals at $0.75, $1.5, $2.5, and $3.5 million. For the earlier period before April 1997, $0.75, $1.5, $2.5, and $3.5 million are the cutoff prices and $1, $2, $3 and $4 million are the comparison group.

We plot the two series of mean of residuals in Figures 9a and 9b. There is clearly more mispricing for the group with the cutoff prices. The mean of the residual over the sample period is about $220,000,000 per month, translating into about $260 million per year.[6] The amount of mispricing is also higher during housing boom between 2004 and 2006. This is due to the higher number of overall transactions. Notice that our measure is likely to underestimate the amount of potential tax evasion: 1) we only consider transactions at or at most $20,000 below the cutoff prices, and 2) we do not consider more luxurious properties. In contrast, the mispricing is close to zero on average for the comparison non-cutoff prices group.

7. Conclusion

The progressive and nonlinear SD schedule in Hong Kong provides incentive for property buyers to bunch at cutoff prices. In this paper, we examine bunching behavior using the Hong Kong housing transaction data. Our results suggest two things. First, despite the fact that the SD schedule in Hong Kong does not feature "discrete jumps" like those in New York-New Jersey and in the UK, there is still strong evidence that property buyers in Hong Kong bunch at cutoff prices of the SD schedules. Second, we exploit the rich information of the properties transacted in Hong Kong to show that there is weak evidence of underpricing at and right below certain cutoff prices, meaning that properties transacted at and right below certain cutoff prices are of a higher quality that their actual transaction prices suggest.

[6] On average there are 188 transactions at or near the cutoff prices per month, implying about a $100,000 underpricing on average.

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Table 1a: First Change in Stamp Duty (SD) schedule

Apr 1, 1996 - Mar 31, 1997

Amount or value of the consideration		
Exceeds	Does not exceed	Rate
	$750,000	$100
$750,000	$809,730	$100 + 10% of excess over $750,000
$809,730	$1,500,000	0.75%
$1,500,000	$1,632,350	$11,250 + 10% of excess over $1,500,000
$1,632,350	$2,500,000	1.50%
$2,500,000	$2,656,250	$37500 + 10% of excess over $2,500,000
$2,656,250	$3,500,000	2.00%
$3,500,000	$3,862,080	$70,000 + 10% of excess over $3,500,000
$3,862,080		2.75%

Apr 1, 1997 - Mar 31, 1999

Amount or value of the consideration		
Exceeds	Does not exceed	Rate
	$1,000,000	$100
$1,000,000	$1,080,010	$100 + 10% of excess over $2,000,000
$1,080,010	$2,000,000	0.75%
$2,000,000	$2,176,480	$15,000 + 10% of excess over $2,000,000
$2,176,480	$3,000,000	1.50%
$3,000,000	$3,187,520	$45,000 + 10% of excess over $3,000,000
$3,290,320	$4,000,000	2.00%
$4,000,000	$4,413,830	$80,000 + 10% of excess over $4,000,000
$4,413,830		2.75%

Note: The tables are reproduced from the Hong Kong Government website at
http://www.gov.hk/en/residents/taxes/stamp/stamp_duty_rates.htm

Table 1b: Second Change in Stamp Duty (SD) schedule

Apr 1, 1999 – Feb 28 2007 (10:59 am)

Amount or value of the consideration		Rate
Exceeds	Does not exceed	
	$1,000,000	$100
$1,000,000	$1,080,000	$100 + 10% of excess over $1,000,000
$1,080,000	$2,000,000	0.75%
$2,000,000	$2,176,470	$15,000 + 10% of excess over $2,000,000
$2,176,470	$3,000,000	1.50%
$3,000,000	$3,290,320	$45,000 + 10% of excess over $3,000,000
$3,290,320	$4,000,000	2.25%
$4,000,000	$4,428,570	$90,000 + 10% of excess over $4,000,000
$4,428,570	$6,000,000	3%
$6,000,000	$6,720,000	$180,000 + 10% of excess over $6,000,000
$6,720,000		3.75%

Feb 28, 2007 - Mar 31, 2010

Amount or value of the consideration		Rate
Exceeds	Does not exceed	
	$2,000,000	$100
$2,000,000	$2,351,760	$100 + 10% of excess over $2,000,000
$2,351,760	$3,000,000	1.50%
$3,000,000	$3,290,320	$45,000 + 10% of excess over $3,000,000
$3,290,320	$4,000,000	2.25%
$4,000,000	$4,428,570	$90,000 + 10% of excess over $4,000,000
$4,428,570	$6,000,000	3%
$6,000,000	$6,720,000	$180,000 + 10% of excess over $6,000,000
$6,720,000		3.75%

Note: The tables are reproduced from the Hong Kong Government website at
http://www.gov.hk/en/residents/taxes/stamp/stamp_duty_rates.htm

Table 2a: Residual Regression (April 1996 – March 1998)

	$1.48 – 1.5 million	**$2.48 – 2.5 million**	**$3.48 – 3.5 million**
Constant	-0.075*** (0.014)	0.030* (0.016)	0.042* (0.021)
Dummy (Apr 1997 and after)	0.006 (0.018)	-0.006 (0.019)	-0.035 (0.024)
Number of Observations	354	329	182
Adjusted R-squared	0.000	0.000	0.010

Table 2b: Residual Regression (April 1996 – March 1998)

	$0.98 – 1.0 million	**$1.98 – 2.0 million**	**$2.98 – 3.0 million**	**$3.98 – 4.0 million**
Constant	-0.101*** (0.028)	0.025** (0.013)	-0.006 (0.025)	-0.023 (0.042)
Dummy (Apr 1997 and after)	-0.251*** (0.045)	-0.074*** (0.016)	0.033 (0.027)	0.031 (0.043)
Number of Observations	81	458	274	186
Adjusted R-squared	0.197	0.023	0.004	0.006

Table 2c: Residual Regression (March 2006 – December 2007)

	\$0.98 – 1.0 million	**\$1.98 – 2.0 million**	**\$2.98 – 3.0 million**	**\$3.98 – 4.0 million**
Constant	-0.108*** (0.021)	-0.033 (0.036)	0.134*** (0.016)	0.042 (0.044)
Dummy (March 2007 and after)	-0.001 (0.023)	0.045 (0.037)	-0.080*** (0.031)	0.001 (0.046)
Number of Observations	722	733	295	200
Adjusted R-squared	0.000	0.004	0.015	0.000

Note: For each month, we regress the real log house price on floor, age and its squared, gross area and its squared, net-gross area ratio and its squared, dummy for clubhouse, bay window size, dummy for swimming pool, and 59 district dummies. The observations at or within 0.02 million below the cutoff prices are not included in the regression. Next, we use the fitted hedonic regression to calculate the residuals for those observations. The residuals are then regress on a constant and a dummy for the policy change.

Figure 1a: Transaction Tax Schedules Before and After the End of March 1997

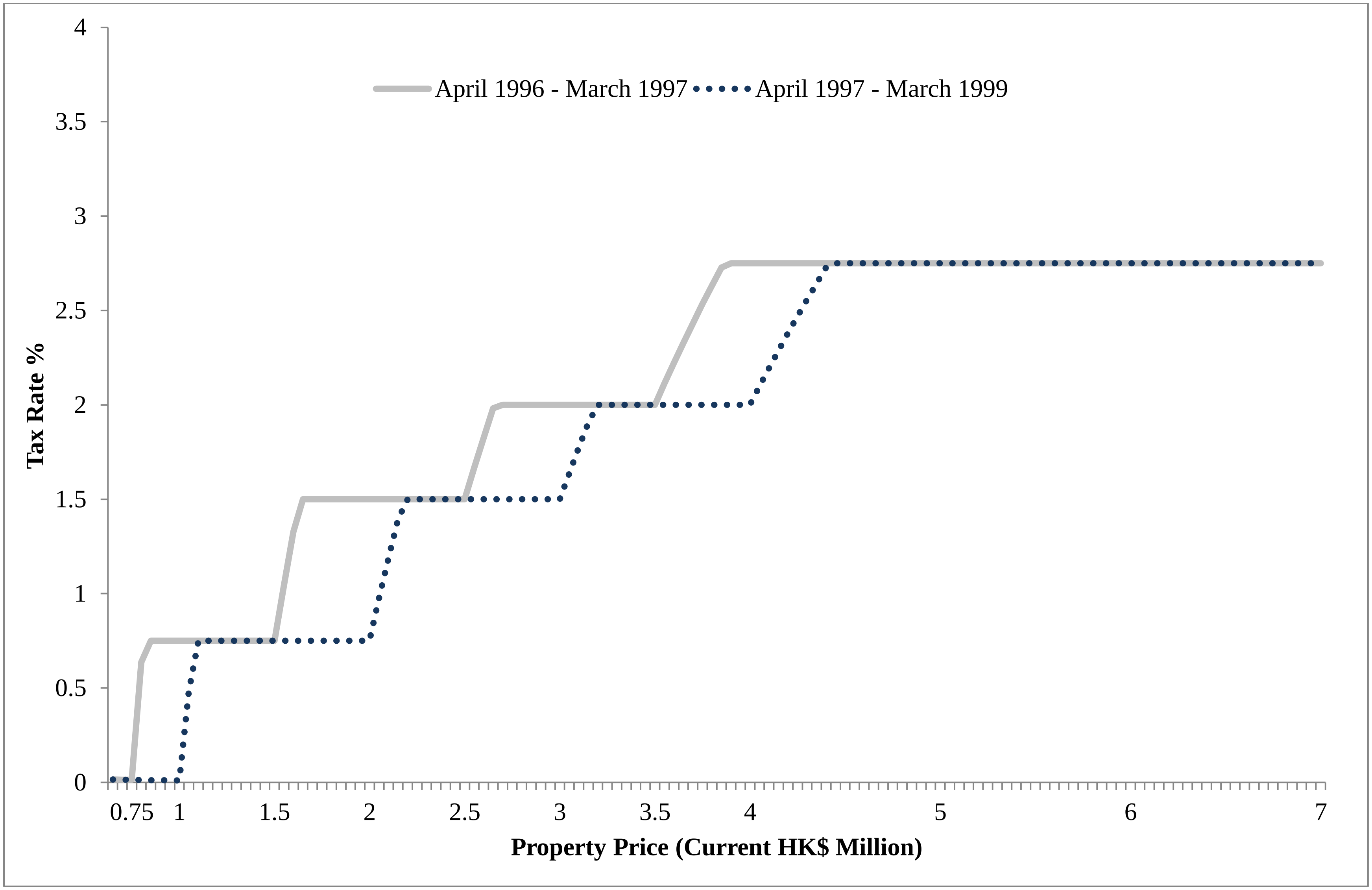
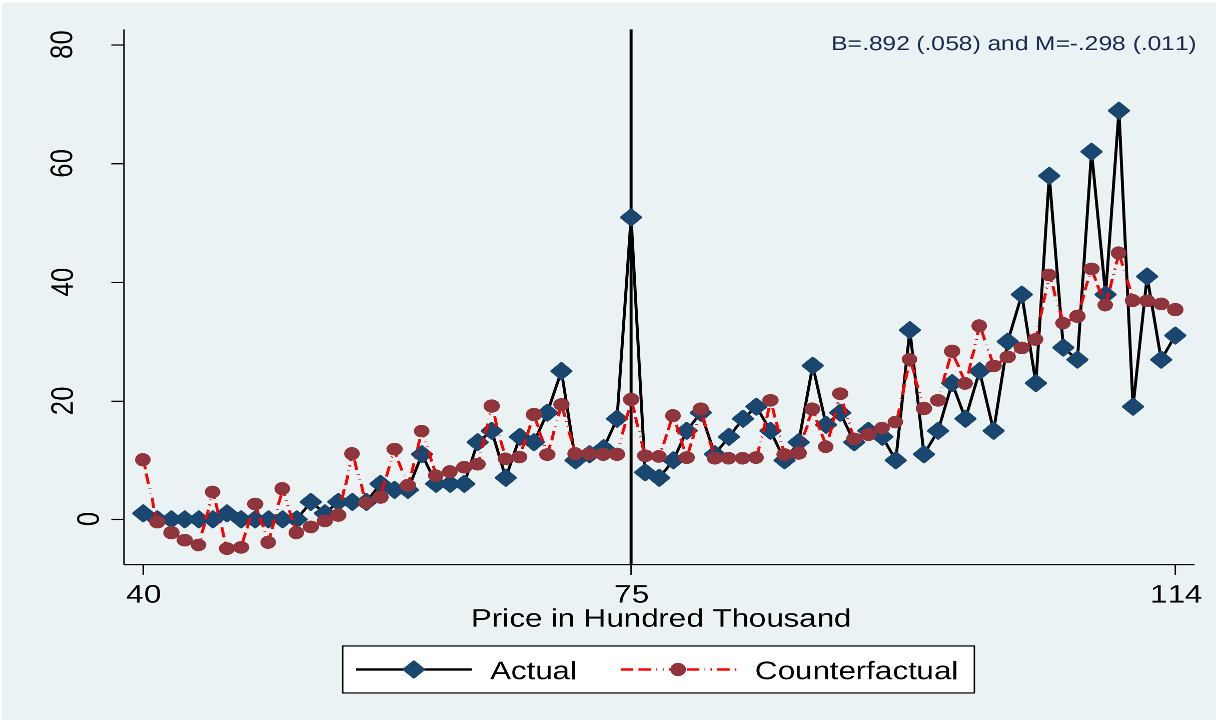


Figure 1b: Transaction Tax Schedules Before and After the End of February 2007

Figure 2a: Bunching Around $0.75 Million and $1.5 Million from Apr 1996 to Mar 1997



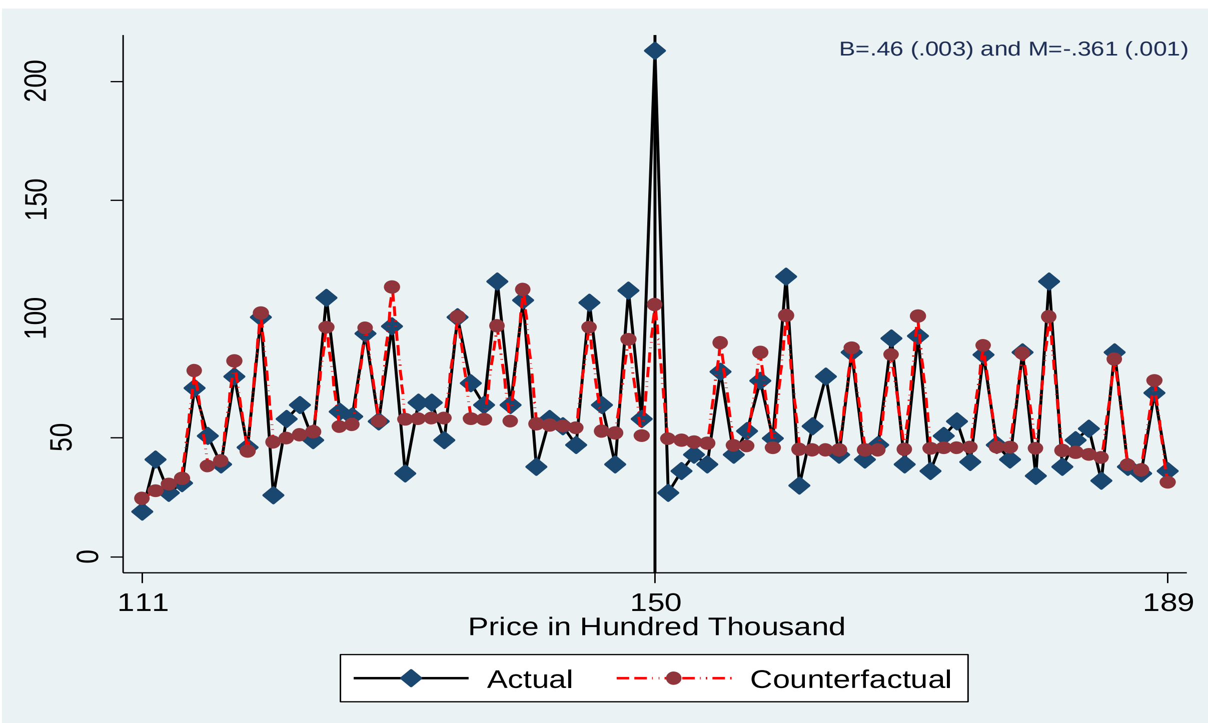
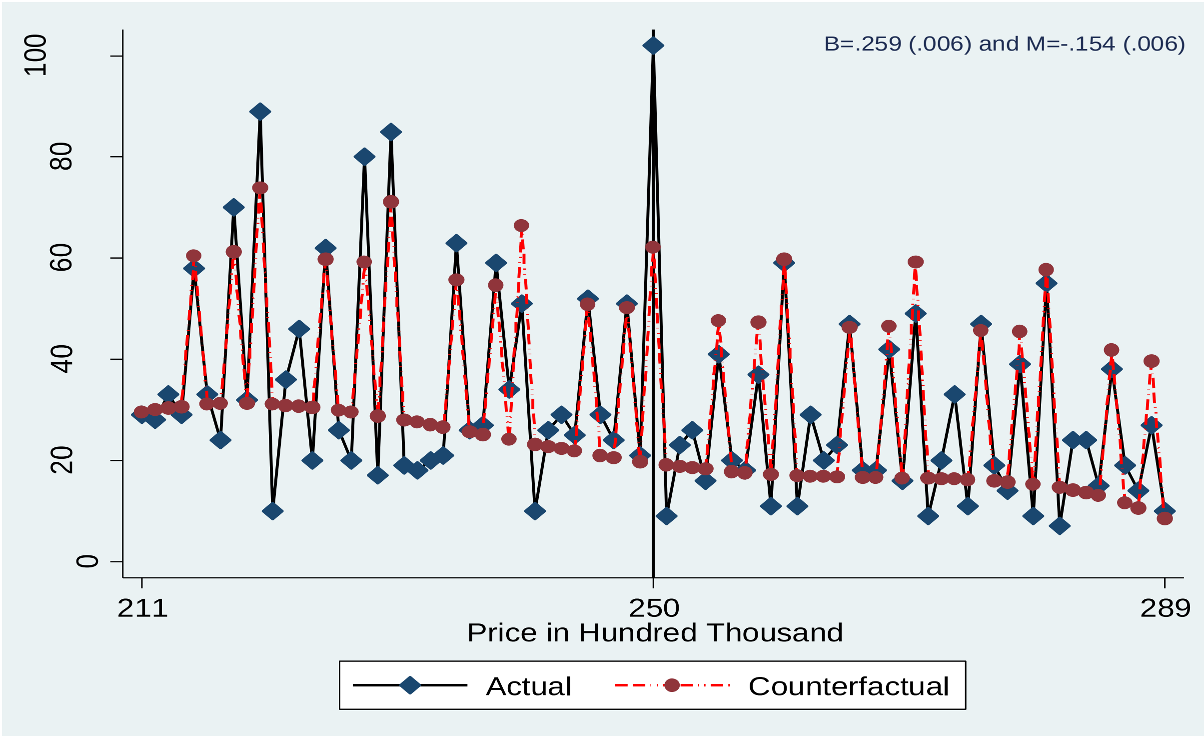
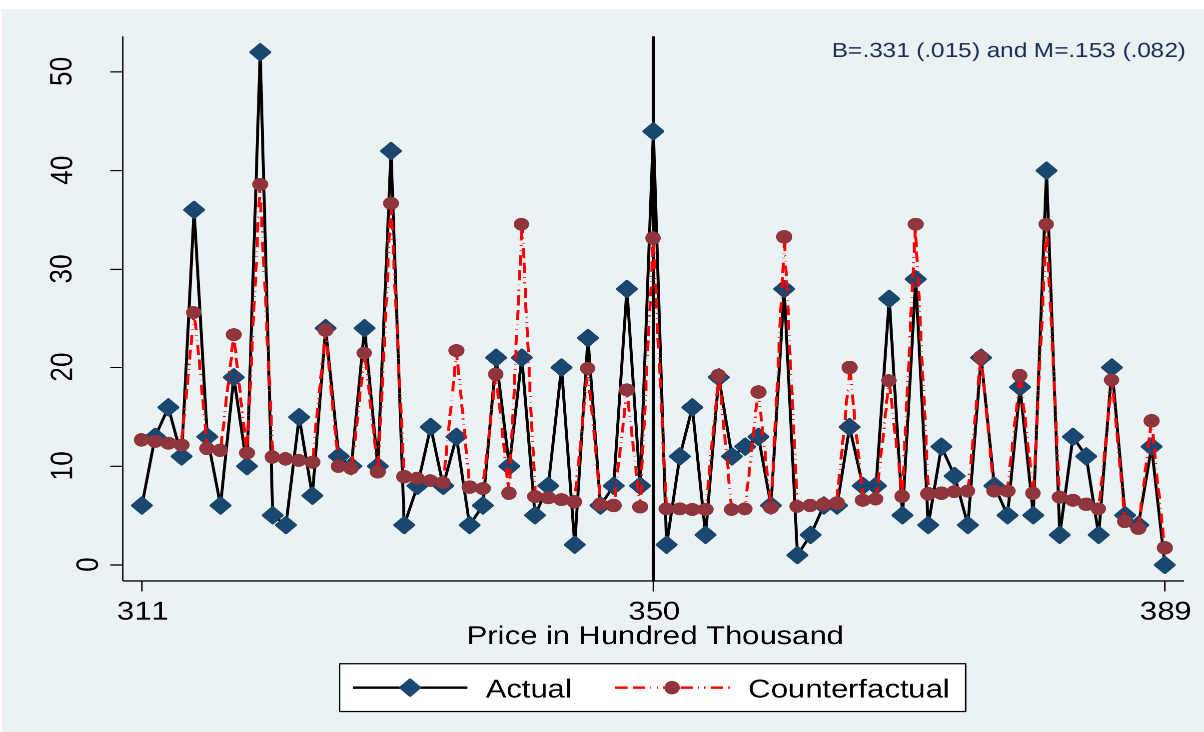


Figure 2b: Bunching Around $2.5 Million and $3.5 Million from Apr 1996 to Mar 1997





Note: The number of transactions for each price bin are fitted as a flexible polynomial. The red line is the fitted polynomial without fixed effects near th cutoff price. The blue line is the actual distribution of transactions. *B* and *M* are measures of the amount of bunching and missing near the cutoff price. Please refer to Section 4 for details.

Figure 3a: Bunching Around $1 Million and $2 Million from Apr 1997 to Feb 2007

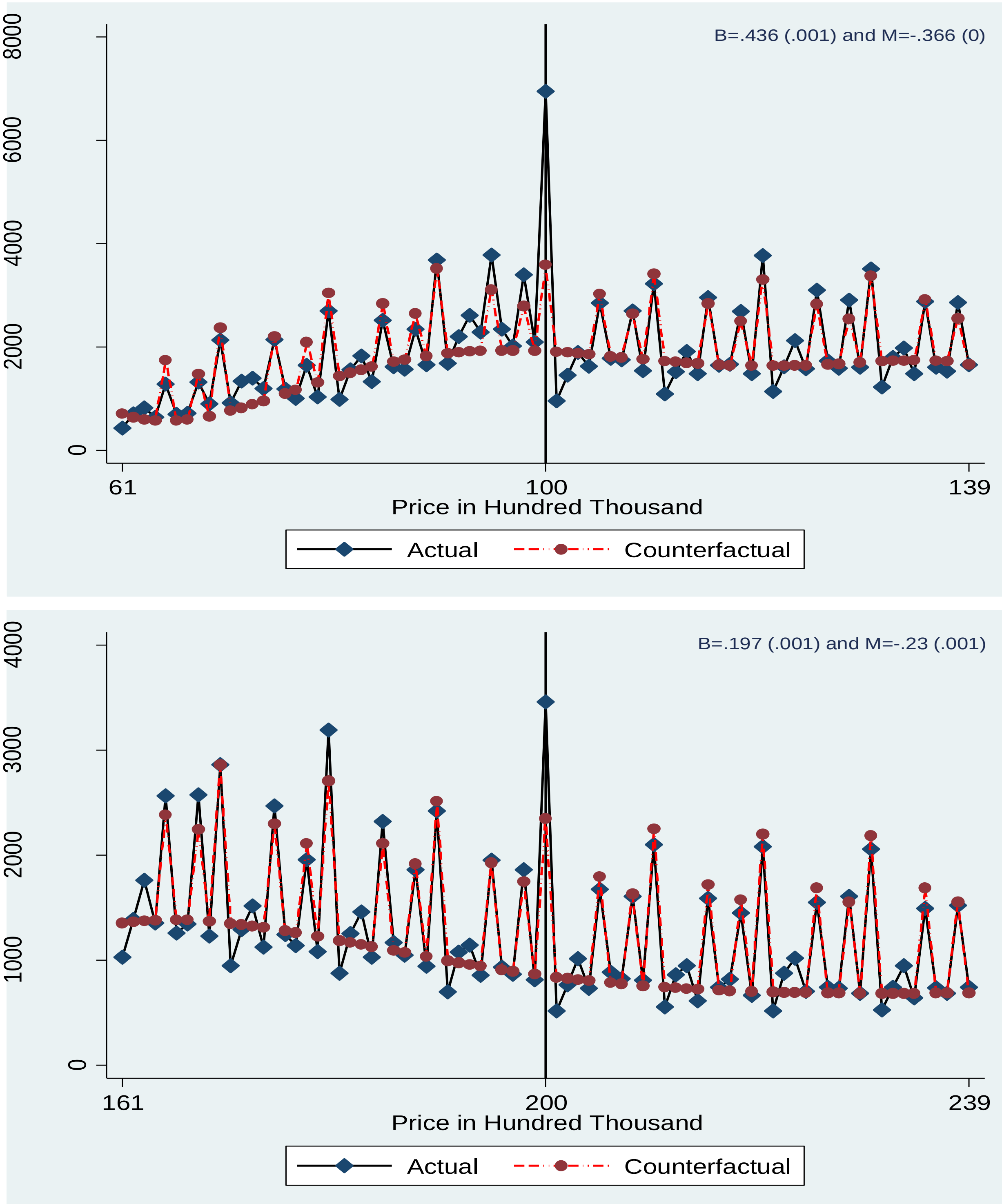
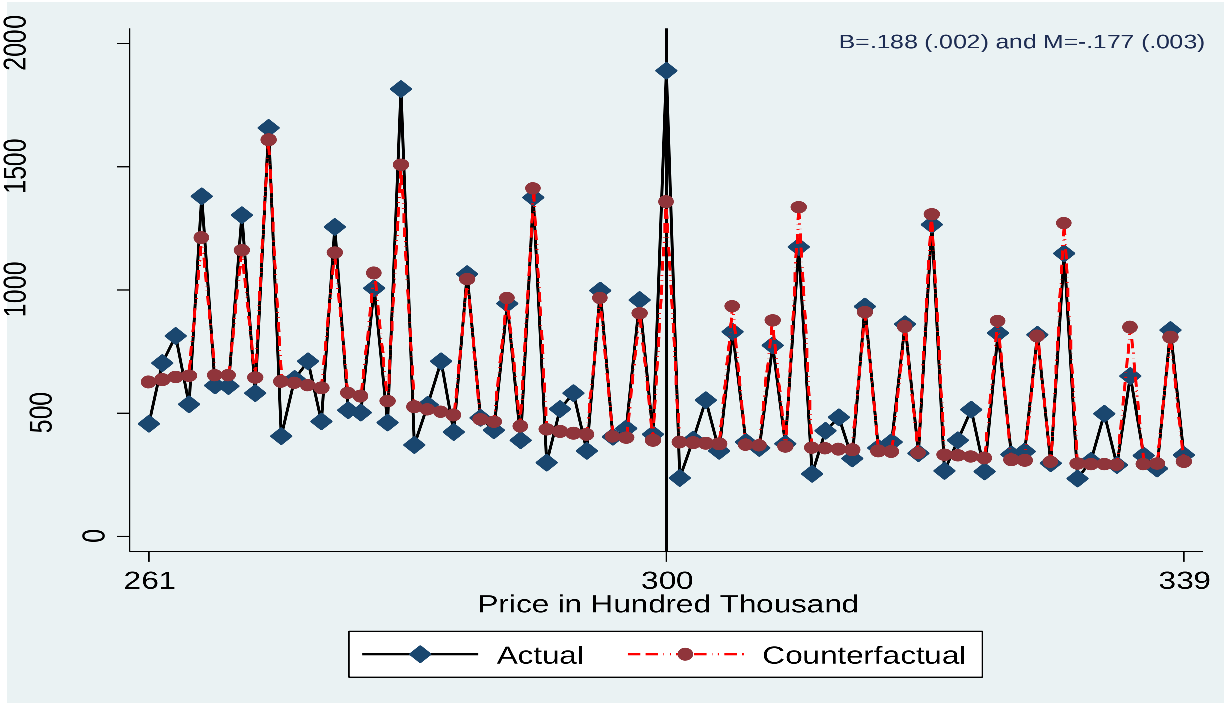
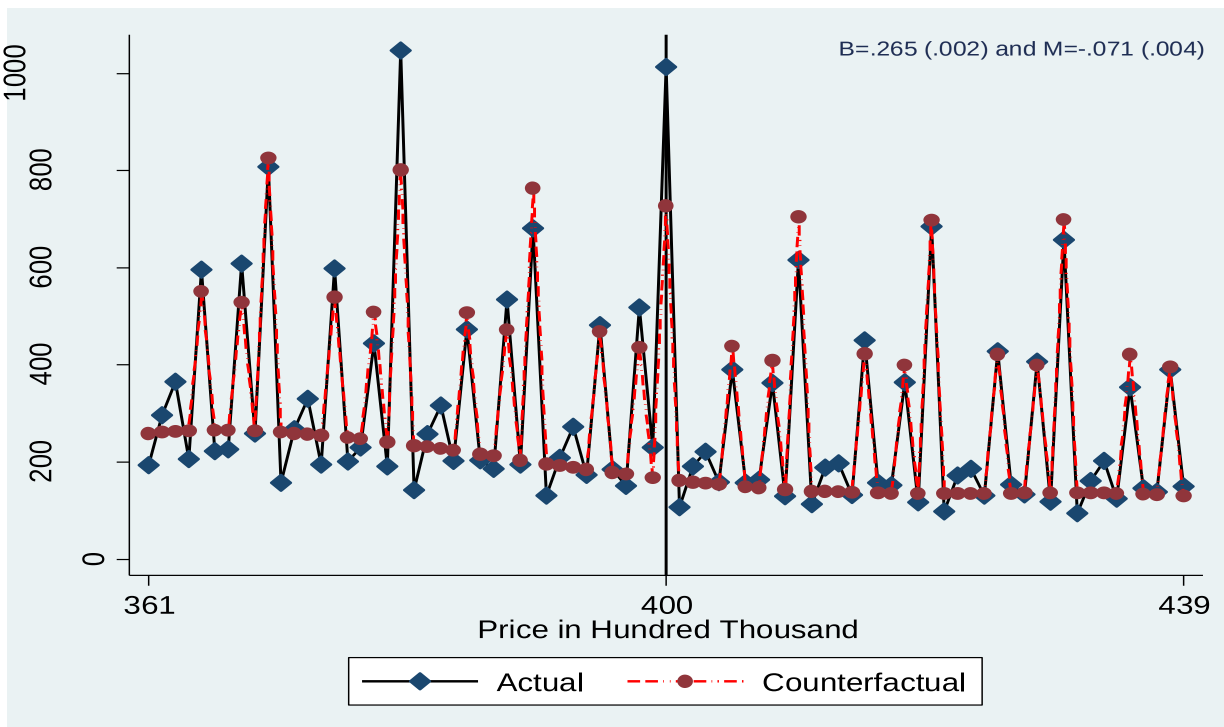


Figure 3b: Bunching Around $3 Million and $4 Million from Apr 1997 to Feb 2007





Note: The number of transactions for each price bin are fitted as a flexible polynomial. The red line is the fitted polynomial without fixed effects near th cutoff price. The blue line is the actual distribution of transactions. *B* and *M* are measures of the amount of bunching and missing near the cutoff price. Please refer to Section 4 for details.

Figure 4a: Bunching Around $2 Million and $3 Million from Mar 2007 to Dec 2007

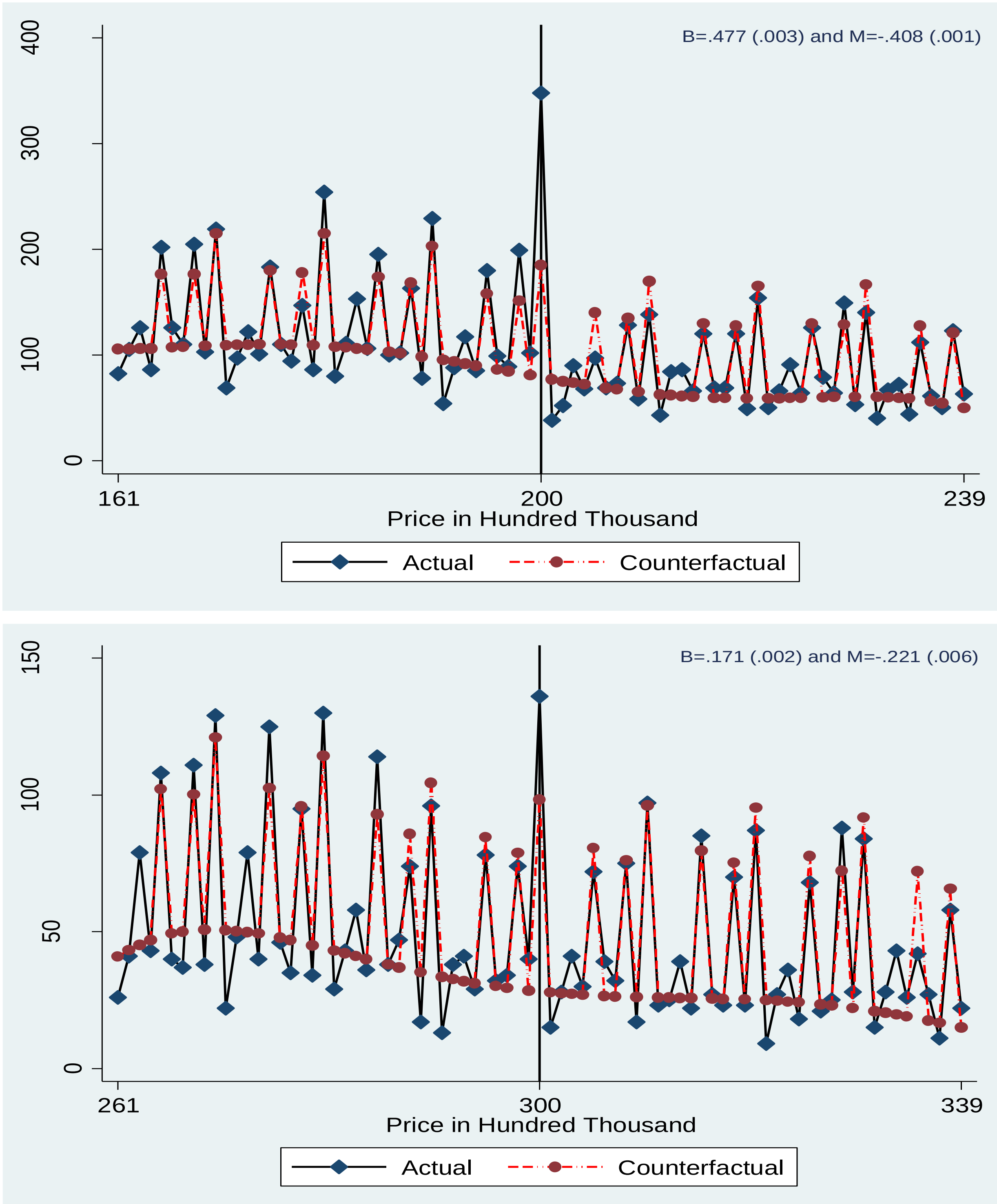
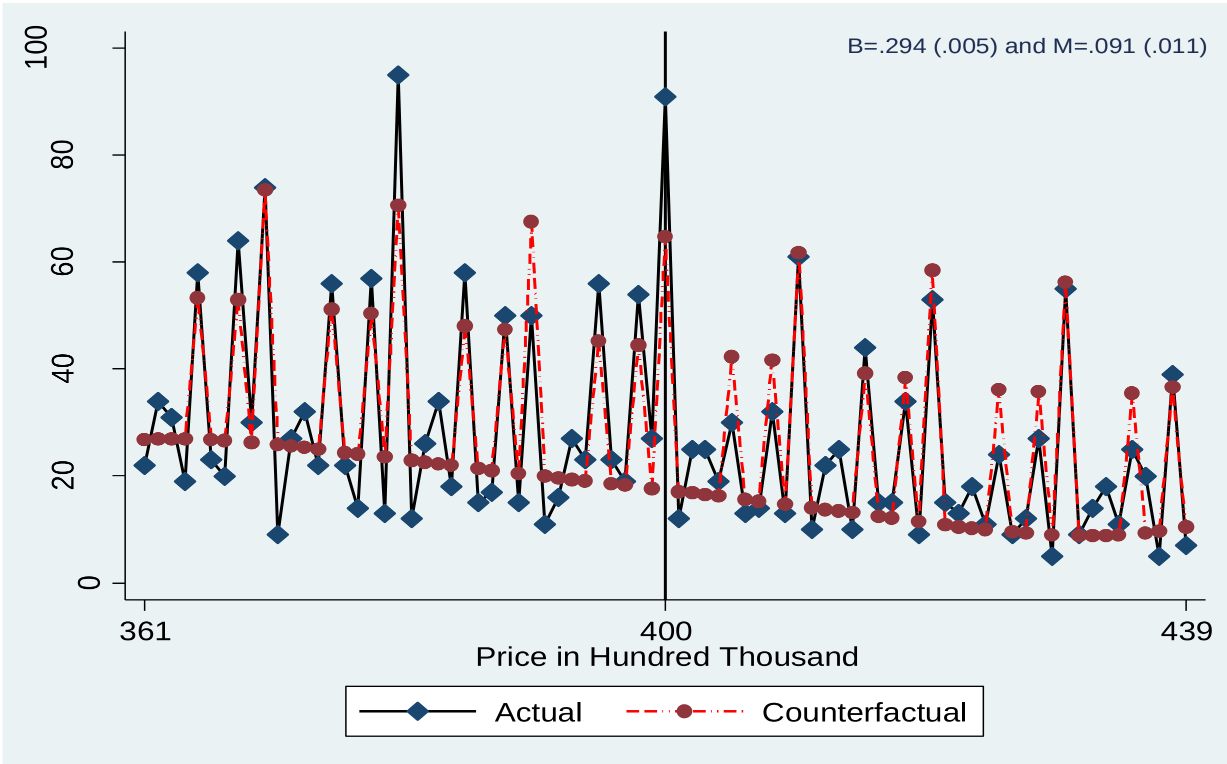
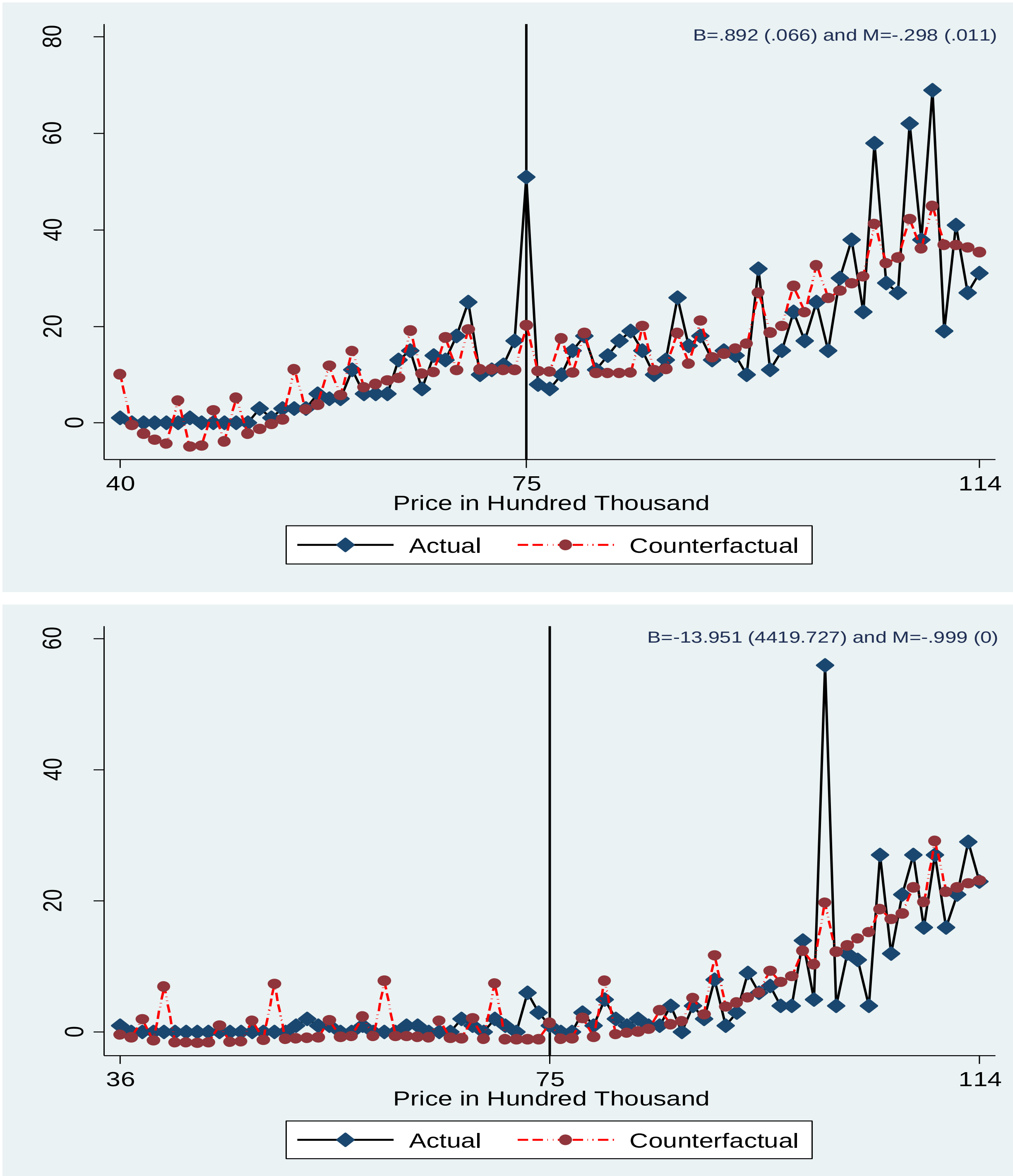


Figure 4b: Bunching Around $4 Million from Mar 2007 to Dec 2007



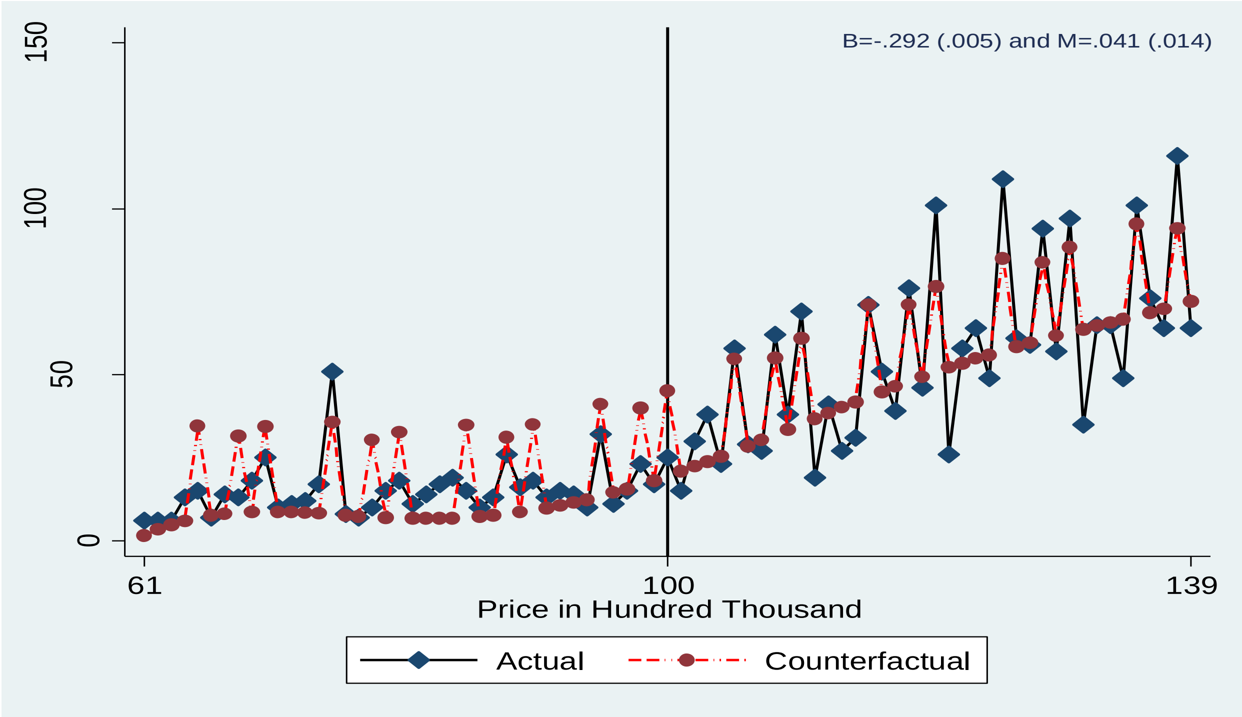
Note: The number of transactions for each price bin are fitted as a flexible polynomial. The red line is the fitted polynomial without fixed effects near th cutoff price. The blue line is the actual distribution of transactions. B and M are measures of the amount of bunching and missing near the cutoff price. Please refer to Section 4 for details.

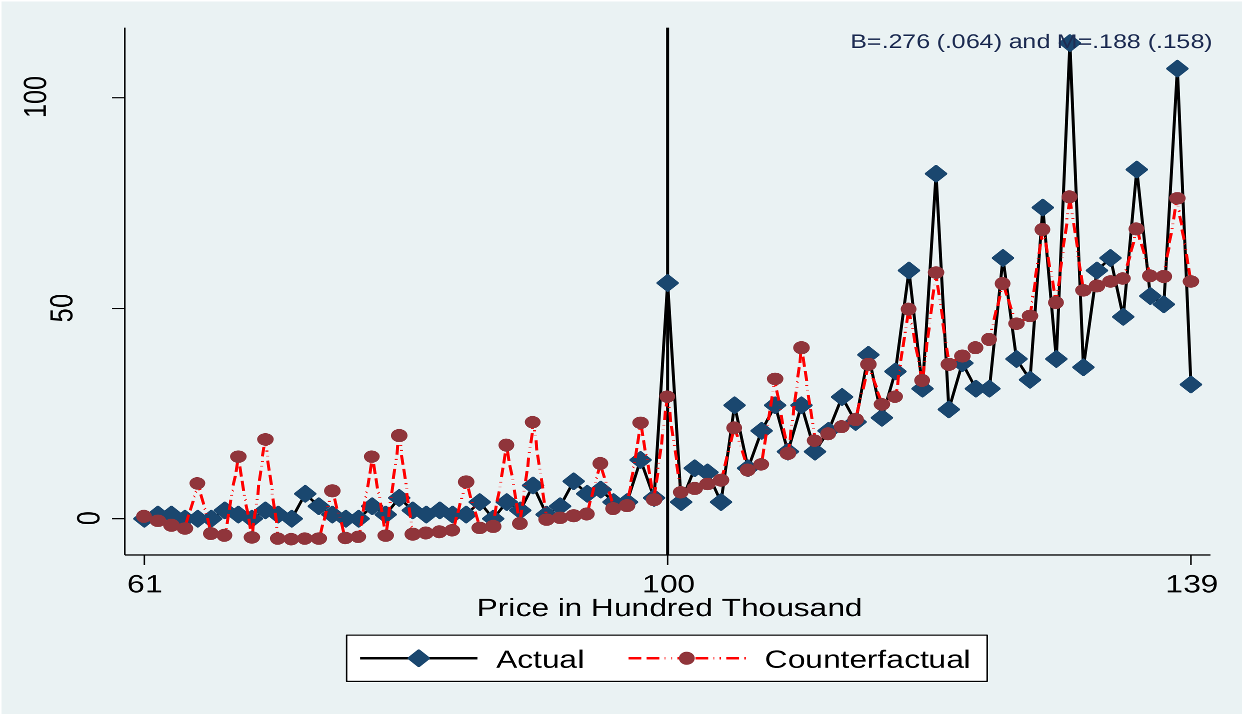
Figure 5: Bunching Around $0.75 Million for the Period Apr 1996-Mar 1997 and the Period Apr 1997-Mar 1998



Note: A flexible polynomial is fitted on the same months of the year before and after the change in the SD schedule. By comparing the two graphs we can detect the disappearance and appearance of bunching and missing.

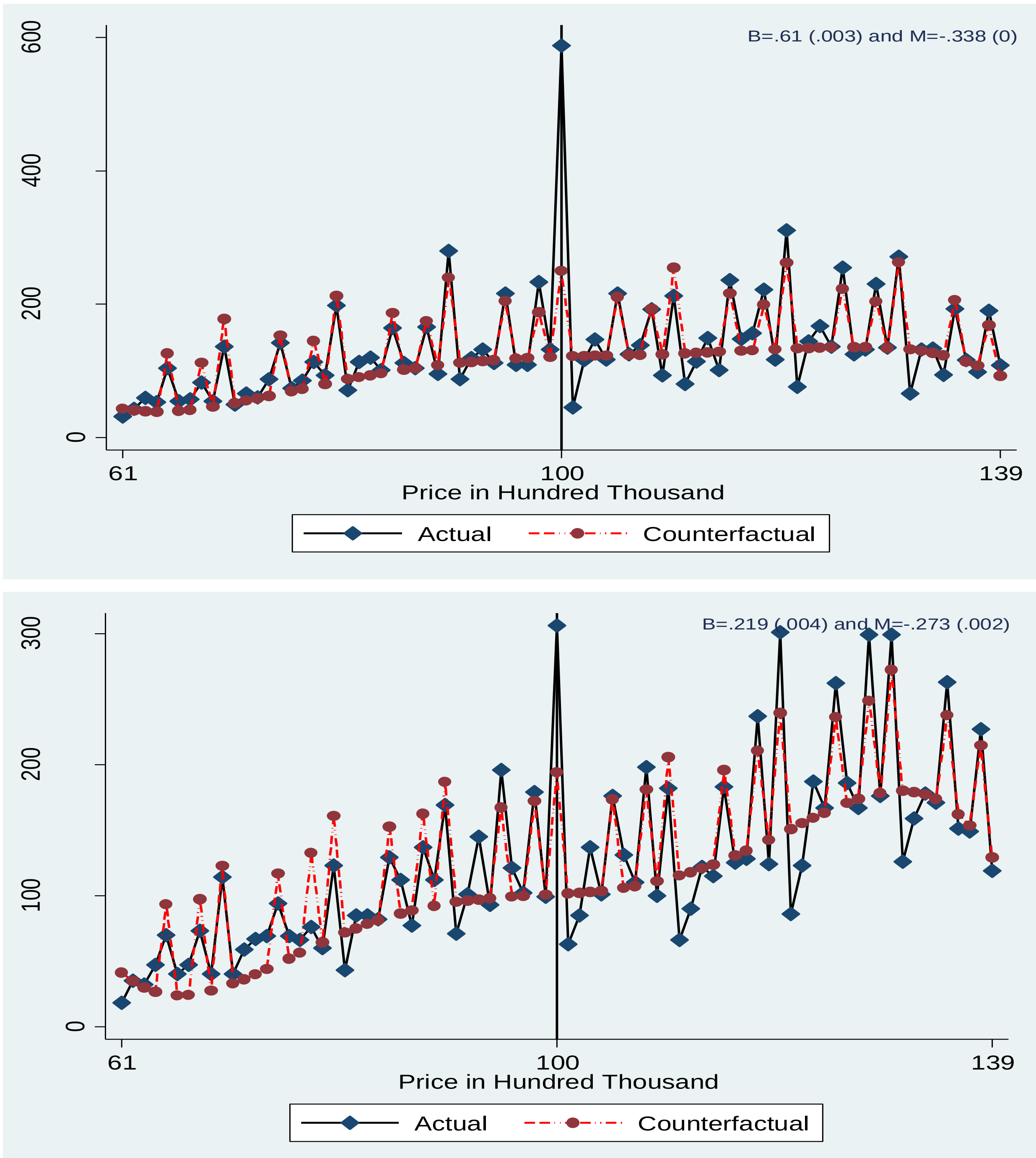
Figure 6: Bunching Around $1 Million for the Period Apr 1996-Mar 1997 and the Period Apr 1997-Mar 1998





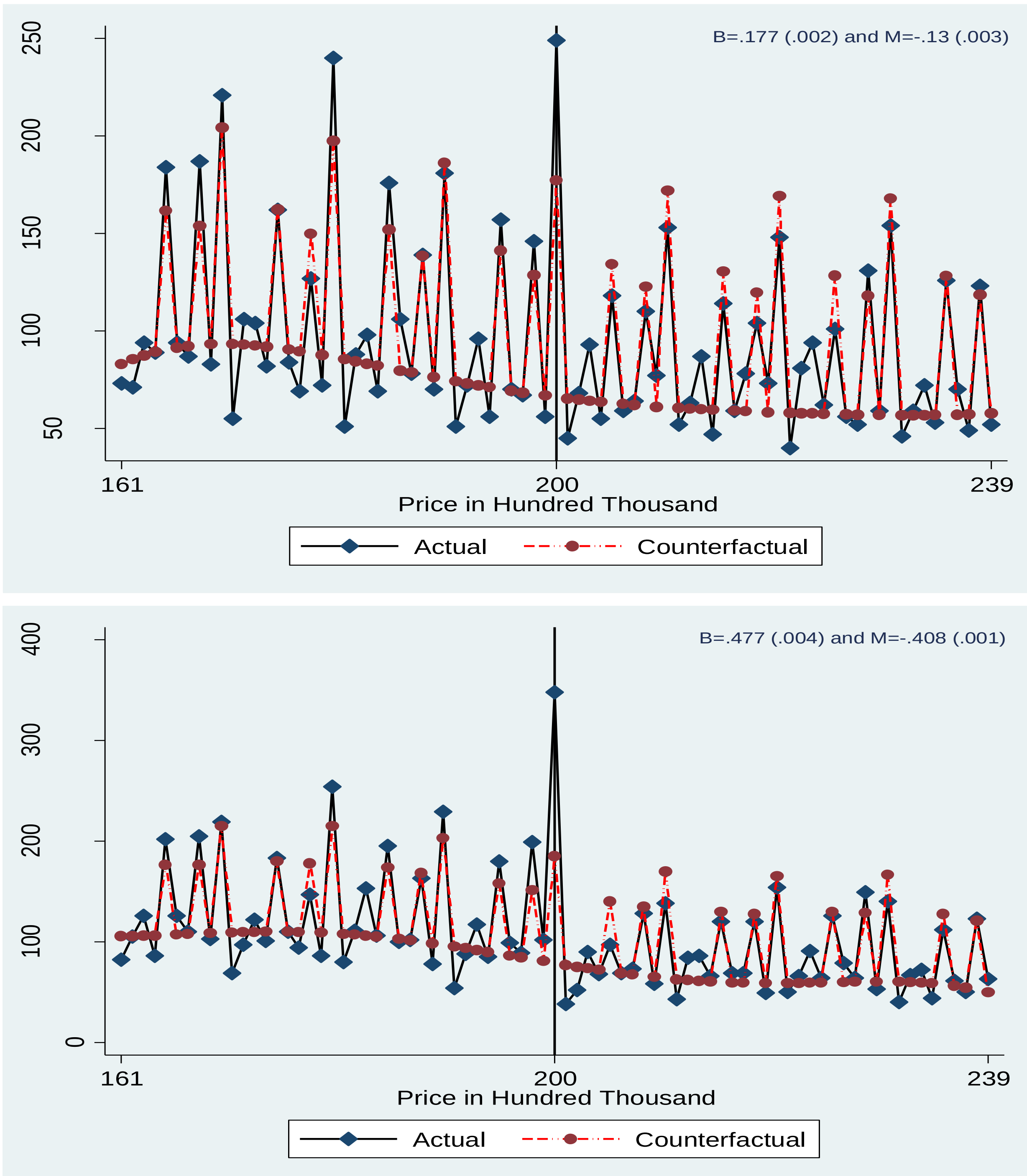
Note: A flexible polynomial is fitted on the same months of the year before and after the change in the SD schedule. By comparing the two graphs we can detect the disappearance and appearance of bunching and missing.

Figure 7: Bunching Around $1 Million for the Period Mar 2006-Dec 2006 and the Period Mar 2007-Dec 2007



Note: A flexible polynomial is fitted on the same months of the year before and after the change in the SD schedule. By comparing the two graphs we can detect the disappearance and appearance of bunching and missing.

Figure 8: Bunching Around $2 Million for the Period Mar 2006-Dec 2006 and the Period Mar 2007-Dec 2007



Note: A flexible polynomial is fitted on the same months of the year before and after the change in the SD schedule. By comparing the two graphs we can detect the disappearance and appearance of bunching and missing.

Figure 9a: Mean of Hedonic Residuals At or Near the Cutoff Prices

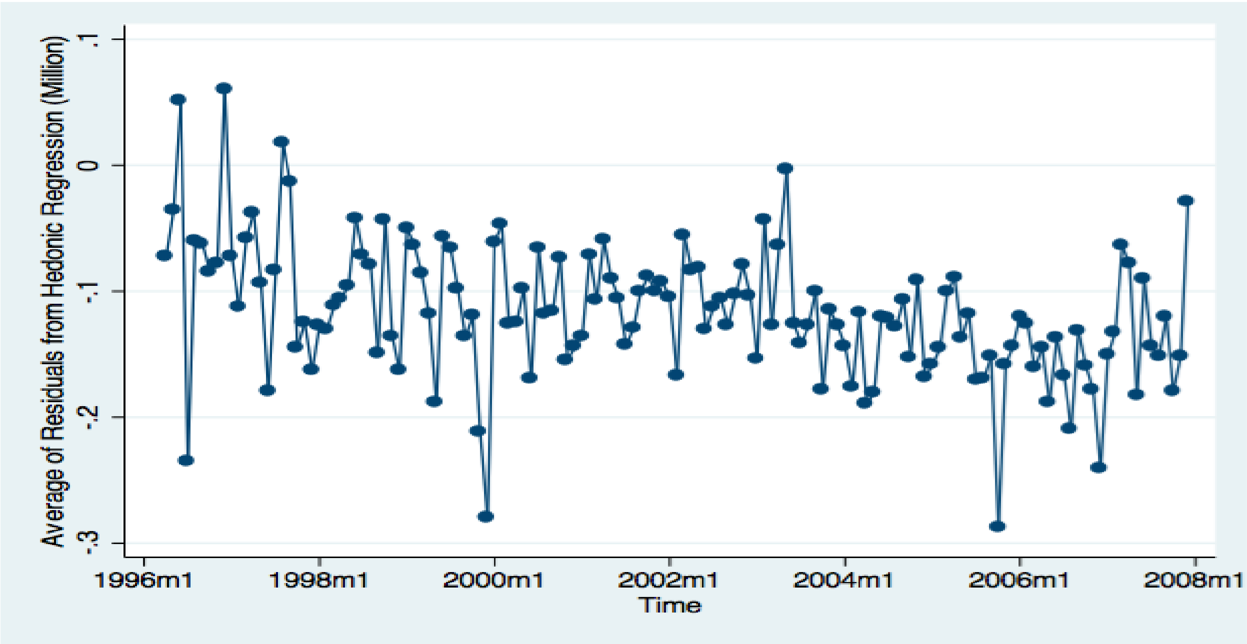
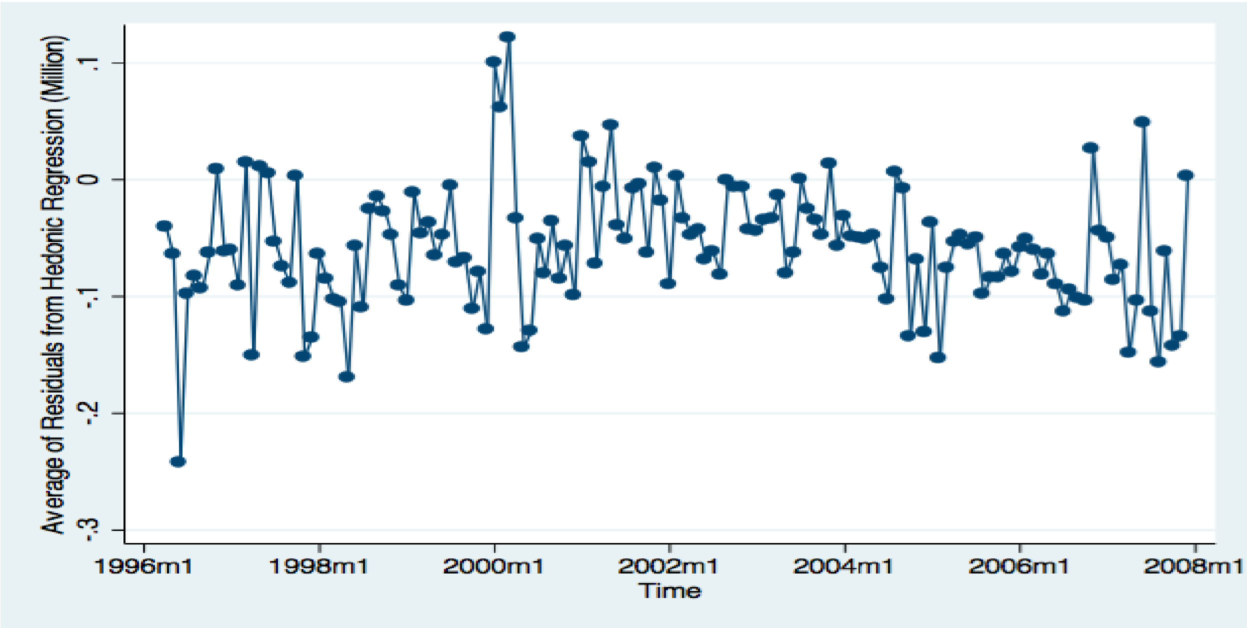


Figure 9b: Mean of Hedonic Residuals At or Near the Non-Cutoff Round-Number Prices



Note: We rerun the hedonic regression using real price instead of log real price. We calculate the mean of the residuals in each month at the cutoff prices (up to $20,000 below) in the first graph. As a comparison, we calculate the mean of the residuals at the non-cutoff but round-number prices in the second graph. All amounts are at May 2005 value, in million.