ANCHORING UNDER CURRENCY SUBSTITUTION: A RATCHET PRICE MECHANISM IN THE HOUSING MARKET

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Abstract

The currency substitution experienced by the Israeli real estate market in the past decades serves as a unique case for studying the effect of the anchoring heuristic on prices. We hypothesize that players utilize current and past exchange rates between the old and new currency to affect the closing price in their favor. Results of micro- and macro-level estimations indicate that exchange rate fluctuations associate with an upward ratchet price effect. Furthermore, we find that the ratchet price mechanism disappears once the currency substitution is completed. These findings provide new evidence of the effect of anchoring on a market whose transactions involve substantial, long-term economic consequences.

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Introduction

Seminal work by Tversky and Kahneman (1974) suggests that people's decisions tend to rely excessively on a specific piece of information. They coined the term "anchoring" for this behavioral heuristic. While the effect of anchoring has been the subject of analysis of numerous experimental studies, the empirical literature focusing on anchoring is fairly sparse. In particular, within the housing literature, only a few empirical studies have focused on the role of anchoring in affecting decision-making and subsequent closing prices. Among those, Genesove and Mayer (2001) show that the purchase price serves to subsequently anchor the unit price at re-sale (also see a related study by Anenberg, 2011); Simonsohn and Loewenstein (2006) and Clauretie and Thistle (2007) demonstrate the importance of the anchor on the willingness to pay among out-of-city movers; and Bokhari and Geltner (2011) and Arbel *et al*. (2014) demonstrate the effect of the anchor in influencing decision-making and subsequent transaction closing price in commercial and public housing markets, respectively.

In this study, we use data from a unique currency substitution experience in the Israeli real estate market to assess the micro- and macro- housing price effect of previous exchange rate (the anchor) in the presence of a dual-currency price. Specifically, in the first half of the 1980s, the Israeli economy underwent an informal dollarization that accompanied the local economic turmoil taking place at the time (Galdino & Leiderman, 2005; Melvin & Peiers, 2007).[1] The real estate market was no exception

[1] The economic crisis manifested itself in, among others, the following developments in macroeconomic indicators: a triple-digit annual inflation rate (greater than 400% at its peak), negative productivity, a growing public deficit (around 20% of GNP at its peak), rising internal and external debt (peaking at about 136% and 84% of GNP, respectively), and increased security expenditures (at about 25% of GNP). During this period of economic instability, the prevailing hyperinflation motivated suppliers to link prices of goods and services to the shekel/dollar exchange rate in order to maintain their real value. As such, prices were determined in dollars and converted to the local currency at the time of payment. The

when dollar-denominated asking prices, negotiations, and closings became common, while only payments were maintained in New Israeli Shekels (hereafter, 'shekels'). This practice, however, which began as a hedge against inflation (Bar-Nathan *et al.*, 1998), was upheld as a norm in the real estate market long after the economy stabilized and the shekel regained its dominance of the economy in the second half of the 1980s (Teichman, 2010). The second half of the 1990s, in contrast, marked a turning point in the real estate market during which a de-dollarization (shekelization) process began and gradually permeated housing market transactions. About a decade later, the currency substitution was completed when shekel-denominated transactions re-dominated the real estate market (see further descriptions of the currency substitution process in the analysis below).[2]

This decade of informal currency substitution in the Israeli housing market serves as a unique case for empirically studying the effect of anchoring on prices. We motivate the empirical tests by means of a parsimonious numerical example in which a dual-currency price emerges among sellers and buyers during currency substitution. We demonstrate that in such circumstances, fluctuations in the exchange rate between the old and new currency allow players to utilize current and *past* exchange rates to affect the closing price in their favor, which in turn may lead to an asymmetric real price effect (see further description and intuition in the next section).

economy thus effectively experienced an informal currency substitution ('dollarization') [see Bruno (1989), Galdino & Leiderman (2005), and Melvin and Peiers (2007)].

[2] Notably, Goldberg and Katz (2014) also study the currency substitution experience of the Israeli real estate market. Their focus, however, is on the macroeconomic sources for the decreased correlation between the consumer price index and the dollar/shekel exchange rate.

We then empirically test for the asymmetrical price effect of exchange rate fluctuations between the old and new currency experienced during the currency substitution in the Israeli housing market. Specifically, based on the universe of all housing transactions in Israel during the shekelization period (1998–2008), we employ both micro- and macro-level tests to assess the effect of positive and negative shocks in the exchange rate on housing transaction prices in the presence of a dual-currency price. The micro-level analysis employs a difference-in-difference approach based on the unique feature of our data that includes both the shekel and the dollar price of each transaction. The macro-level approach involves an impulse response analysis by which we assess the long-term asymmetric effect of a negative and positive shock in the shekel/dollar exchange rate on the housing price index during the currency transition period. Finally, we examine the robustness of our findings to issues of sampling and test specifications.

Results provide solid evidence of an asymmetric effect (related to the dual-currency price) of shekel/dollar depreciation and appreciation on housing prices during the currency substitution (shekelization) period. In particular, our micro-data test demonstrates that controlling for housing characteristics, a 1% increase (decrease) in the shekel/dollar exchange rate associates with about a 1% increase in (a zero net effect on) the price of shekel-denominated, as compared to dollar-denominated, housing transactions. Moreover, macro-data analysis reveals that controlling for macro-economic conditions, a 1% increase (decrease) in the shekel/dollar exchange rate associates with a long-term 0.45% increase (zero net effect) in the housing price index. We further find that this pattern of asymmetric price index effect is more salient when transaction volume increases, though it maintains even when the number of transactions in the market is relatively low. Moreover, the price effect disappears once the currency

substitution process is completed (i.e., when market players no longer base decisions on a dual-currency price). The results are robust to sampling and test design issues. Outcomes thus indicate an upward ratchet price mechanism that associates with the (exchange rate) anchoring heuristic during a currency substitution period.[3]

Our findings yield several main contributions. First, we demonstrate the asymmetric price effect of an anchor (in the form of a reference exchange rate) in a market whose transactions involve substantial, long-term economic consequences. Moreover, unlike previous research, we not only find the micro-level effect of the anchoring heuristic, but also detect its long-term macro-level consequences. Also, our outcome on the upward ratchet price effect of the currency substitution process indicates that in the bargaining between the seller and the buyer, the former tended to dominate by exploiting the dual-currency price in her favor.[4] Furthermore, by documenting the real price effect of a currency substitution process, our results are added to the existing evidence on the price effect of currency substitutions.[5] Finally, as our results include an

[3] Our empirical evidence on the ratchet price mechanism in the housing market under currency substitution is consistent with the concept of asymmetric reaction to changes in economic factors shown in other contexts. For example, Duesenberry (1952) finds that consumption asymmetrically reacts to changes in income; Weitzman (1980), Freixas, Guesnerie, and Tirole (1985), Ickes and Samuelson (1987), Litwak (1993), and Choi and Thum (2003) discuss the ratchet effect in employer production aspiration; Ezzamel and Watson (1998) and Bizjak (2008) find that executive compensation only tends to be updated upward; and Khandani, Lo, and Merton (2009) discuss upward ratchet risk mechanism under the refinancing option framework. Finally, Solow (1980), Kuran (1983), and Shirvani and Wilbratte (1999) show ratchet price effects in different settings than the one under consideration here.

[4] In that regard, our paper also relates to the real estate literature on seller and buyer bargaining power [see, e.g., Yavas and Yang (1995) and Coles and Muthoo (1998)].

[5] In contrast to our anchoring heuristic focus, existing empirical evidence on the price effect of a currency substitution concentrates on factors such as money illusion effect [Cannon and Cipriani (2006); Gamble *et al.* (2002); Gamble (2007); Jonas *et al.* (2002); and Kooreman *et al.* (2004)]; compression effect [Marques (2007)]; illusionary price effect [Traut-Mattausch *et al.* (2004, 2007)]; and emotional attachment effect [Tyszka and Przybyszewski (2006)]. Somewhat more closely related to the asymmetric price effect explored in our study, a number of studies focus on the imperfect information and confusion that may affect prices during currency substitution. For example, Berardi *et al*. (2014) document various sub-markets of the French restaurant industry in which the confusion associated with the euro changeover is more (and less) likely to be exploited by sellers, while Dziuda and Mastrobuoni (2009) show that

asymmetric price effect of the currency substitution process, our findings stress the potentially important role of public policy measures designed to accelerate and truncate the currency transition period.[6]

The paper proceeds as follows. Section 2 presents that underlying intuition motivating the prevalence of a ratchet price mechanism generated under a dual-currency price with an anchor exchange rate. Section 3 describes the data and presents related summary statistics. Sections 4 and 5 present the empirical model, results, and robustness tests of the micro-level and macro-level analyses, respectively. Finally, Section 6 provides a summary and concluding remarks.

Intuition and Hypotheses

Consider a (pre-currency substitution) housing market in which all transactions are conducted in a single currency—the dollar. Let the price of a dwelling unit be 100 dollars and suppose, without loss of generality, that all dwelling units are identical. Suppose that the current exchange rate is 1.5 shekels per dollar. It follows that the equivalent shekel price of a dwelling unit is 150 shekels.

Now, suppose that the dollar depreciates such that the new exchange rate is 1.4 shekels per dollar. Then, the shekel equivalence of the dollar price decreases from 150 to 140 shekels. If the 100-dollar price materializes into a closing price, then, in shekel terms,

sellers of relatively cheaper goods in particular tend to exploit buyers' imperfect information [also see Del Missier *et al.* (2007)]. Finally, see Parsley and Wei (2008), who find no significant price effect associated with currency substitution.

[6] This implication of our research contradicts the suggestion of Hobijn *et al*. (2006) to extend the currency substitution period; importantly, however, unlike our framework, their proposition refers to a situation in which the exchange rate is fixed.

the dollar depreciation generates a 10-shekel loss to the seller and a 10-shekel gain to the buyer. Likewise, if the dollar appreciates (say, from 1.5 to 1.6 shekels per dollar), then reaching a closing price equal to 100 dollars generates a shekel loss to the buyer and a shekel gain to the seller.

Suppose, however, that a currency substitution (shekelization) is initiated and housing units are now transacted in either dollars or shekels (i.e., a dual-currency—dollar and shekel—price emerges). As the current shekel/dollar exchange rate equals 1.5, the new shekel price is equal to 150 shekels. Under this dual-currency price regime, if the dollar now depreciates to 1.4 shekels per dollar, then the seller may attempt to avoid the shekel price effect of the depreciation in the value of the dollar by opting for a shekel transaction and negotiating for the shekel price under the pre-depreciation exchange rate (i.e., 150 shekels corresponding to the 1.5 shekels per dollar) rather than the 100-dollar price. At the same time, the buyer may try to exploit the depreciation of the dollar by opting for a dollar transaction, negotiating for the 100-dollar price (which now equals 140 shekels under the post-depreciation exchange rate).

Conversely, if the dollar appreciates from 1.5 to 1.6 shekels per dollar, then the seller may opt for a dollar transaction by negotiating for the 100-dollar price (which is now equal to 160 shekels) and thus benefit (in shekel terms) from the dollar appreciation. In contrast, the buyer may now opt for a shekel transaction, negotiating for the pre-appreciation shekel price (150 shekels corresponding to the 1.5 shekels per dollar), thereby avoiding the greater shekel price that accompanies the 100-dollar transaction under dollar appreciation (which would now equal 160 shekels).

Assuming that under currency substitution (from dollar to shekel), sellers and buyers might anchor on the previous exchange rate and correspondingly opt for a closing price in the currency that maximizes their benefit, we argue that:

Case 1: If the *seller* maintains some bargaining power, then, following the dual-currency price that emerges during a currency substitution period, *depreciation* in the shekel value of the dollar results in a greater closing price than would have otherwise been attained in the pre-currency substitution period. In particular, if the seller dominates the bargaining process, then depreciation (appreciation) in the value of the dollar entails no change (an increase) in the shekel closing price; hence, under dual-currency prices, exchange rate fluctuations produce an upward ratchet shekel price mechanism.

Case 2: If the *buyer* maintains some bargaining power, then, following the dual-currency price that emerges during a currency substitution period, an *appreciation* in the shekel value of the dollar results in a lower closing price than would have otherwise been attained in the pre-currency substitution period. In particular, if the buyer dominates the bargaining process, then appreciation (depreciation) in the value of the dollar entails no change (a decrease) in the shekel closing price; hence, under dual-currency prices, exchange rate fluctuations produce a downward ratchet shekel price mechanism.

Description of the Sample

The raw micro-data includes the universe of all housing market transactions in Israel over the period 1998–2008 (a total of 478,100 transactions).[7] Following the omission of error reports, missing observations, and unclassifiable transactions (see details in the next section), the final sample consists of 279,630 observations.[8]

Table 1 includes summary statistics on the sample of transacted assets. As indicated in the table, the average (non-quality-adjusted) per-square-foot price is 193 dollars. The table also presents the dwelling units' structural and locational characteristics controlled for in the analysis. These characteristics include the area of the dwelling unit in square feet (*AREA*), the number of rooms in the dwelling unit (*ROOMS*), the age of the structure at the time of transaction (*AGE*), and a series of dummy variables representing the unit type (such as penthouse, duplex, detached, attached, and ground-level condominium apartment) (*TYPE*2–*TYPE*8, where the base group is a condominium apartment). As the table indicates, the typical housing unit is an 885 square-foot, 3- or 4-room condominium apartment in a structure that is 25 years old at

[7] As the earliest publicly available micro-data on housing transactions, published by the Israel Tax Authority, begins in 1998, we examine only the shekelization experience of the market and cannot study the preceding dollarization. As noted by Offenbacher and Stein (2003), however, the share of shekel transactions prior to 1998 was relatively minimal, implying that our data capture the greatest part of the shekelization period. Even more important, had shekelization begun to some extent prior to 1998, there does not seem to be any reason to expect that it would have had any effect that is different from what we find for the post-1998 period.

[8] It should be noted that a legislative policy initiated by the parliament in June 2002 imposed shekelization on *primary* real estate market transactions (i.e., newly constructed units) whereby contractors were legally obligated to market and offer their merchandise in shekels. This policy, however, did not regulate *secondary* market transactions (i.e., repeat sales), leaving to seller-buyer negotiation the choice of currency in which each transaction would be conducted. We thus omit primary market transactions—about 20% of total transactions—from our analysis, as the currency in which those transactions were conducted was not determined by the negotiating parties. (In general, secondary market transactions constitute about 80% of all housing transactions in Israel—see Israel Ministry of Finance, 2014, in http://mof.gov.il/reportsandreviews/skirot%20nadlan/skiratnadlan_2014q4.pdf [last visited December 9, 2015]).

the time of transaction. A locational fixed-effect control includes a categorical variable for the city where the housing unit is located.[9]

Table 1 also presents summary statistics on the log of the monthly nominal shekel/dollar exchange rate, EX_t. The average value of EX_t over the examined period (1998–2008) is 1.455. In addition, ΔEX_t^- and ΔEX_t^+ denote the difference $EX_t - EX_{t-1}$ when $EX_t - EX_{t-1} < 0$ and $EX_t - EX_{t-1} > 0$, respectively (i.e., when depreciation and appreciation in the shekel value of the dollar occurs, respectively). The average monthly depreciation (the average of ΔEX_t^-) is equal to 0.008, whereas the average monthly appreciation (the average of ΔEX_t^+) is equal to 0.007, with a standard deviation of 0.011 and 0.012, respectively. During the period under examination (1998–2008), the dollar depreciated over 51.7% of the periods (months) and appreciated over 48.3% of the periods. The average rate of change in the shekel-dollar exchange rate over the entire period was 0.05% (with a standard deviation of 2.04%).

As described below, we complement the micro-data analysis with a macro-level test to assess the currency substitution effect on the housing price index. Table 2 presents summary statistics of the variables included in the macro-level test over the period 1998–2008. These variables include the log of the monthly housing price index (*HPI*),[10] the log-difference of the housing price index (ΔHPI), the log of the dollar-shekel

[9] As our analysis includes monthly hedonic price estimations (see Section 4 below), we omit observations in municipalities with fewer than five monthly transactions—a total of about 5% of the observations.

[10] The housing price index (*HPI*) is based on a hedonic price estimation that considers housing units' characteristics (including the city in which a unit is located, number of rooms, total area in square meters, age of the structure, and socio-economic score of the statistical area where the unit is located, as defined by the Israel Central Bureau of Statistics, and a time fixed-effect dummy variable). For more on the construction of *HPI*, see Sayag (2010).

exchange rate (*EX*), the log-difference of the dollar-shekel exchange rate (Δ*EX*), the log-difference of the consumer price index (excluding housing) (Δ*CPI*), the level-change in the yield on the one-year shekel treasury bill (Δ*TBILL*), the level-change in the yield difference on the one-year (non-indexed) shekel and dollar treasury bills (Δ*BILLDIF*), the level-change in the mortgage rate (Δ*MORTGAGE*), the level-change in unemployment rate (Δ*UNEMPLOYMENT*), the log-difference of the average wage (Δ*WAGE*), the log-difference of the cost of the construction index (Δ*CCI*), the log-difference of the population size (Δ*POP*), and the housing construction completions index (*COMPLETIONS*). Notably, the average monthly rate of change of the housing price index (Δ*HPI*) was roughly zero (with a standard deviation of 1.1%); and the average monthly inflation rate (excluding housing) (Δ*CPI*) was just above 0.2% (with a standard deviation of 0.5%).

Micro-Level Analysis

Next, we focus on assessing whether exchange rate fluctuations entail a real price effect under currency substitution. The micro-level statistical test of the price effect of shekelization follows a preliminary analytical step that classifies the observations into originally dollar- and shekel-denominated transactions as described below.

CLASSIFYING SHEKEL- AND DOLLAR-DENOMINATED TRANSACTIONS

Our micro-level data contain housing transaction prices—each recorded in both shekels and dollars, as reported by the seller to the Israel Tax Authority.[11] These closing prices

[11] Israeli law requires sellers to report the sale transaction for tax purposes. The report includes the closing price denominated in both shekels and dollars, the closing date, and the asset's fundamental physical amenities. Inspection of the recorded shekel and dollar prices for each transaction shows that in 98.5% of the transactions, the ratio of these prices is equal to the daily nominal exchange rate (up to three digits

represent the end product of a price negotiation between sellers and buyers. The specific currency (dollar or shekel) in which the transaction was originally conducted, however, is unobservable. Thus, a key preliminary step is to recover the denominated currency of each transaction.

Table A1 in the appendix shows the principles of the algorithm by which we score the dollar and shekel figures of each transaction according to the degree of 'roundness' of the recorded prices. We assume that a 'rounder' price (in either shekels or dollars) represents the currency that was actually employed in conducting the transaction (while the other was simply the one to which the closing price was converted at the current exchange rate of the reporting date). For example, if the recorded prices of a transaction were, say, 950,000 shekels and 256,757 dollars (representing a current exchange rate of 3.7 shekels per dollar), our algorithm would determine that the transaction was originally denominated in shekels.[12] Table A2 in the appendix presents the distribution of the difference between the dollar and shekel price classification scores per transaction. It follows that less than 10% of the observations ended up as indecisive cases and were omitted from the estimation (e.g., when the transaction price was 1,200,000 shekels and 300,000 dollars, when one dollar was equal to four shekels).

after the decimal point) that was recorded on the date of the transaction. In only 0.8% of the observations, the ratio of the recorded prices differed by 10% or more from the daily nominal exchange rate (these cases were removed from the dataset).

[12] As detailed in Table A1, our algorithm scores each price as a function of the number of zeros ending the price (in dollars and shekels) and determines the currency originally denominated in the transaction as the one with the higher score (a greater number of zeros). If, however, the number of zeros in the dollar and shekel prices is the same, then a "5" as a first non-zero digit on the right-hand side of the number breaks the tie. For example, if the dollar and shekel prices of a transaction are 458,500 and 91,700, respectively (implying a conversion rate of five shekels per dollar), the algorithm determines an originally shekel-denominated transaction. Finally, prices ending with digits repeating three times (such as "999") are scored as "000." In the analysis below, we conduct a robustness test of the results to stricter criteria regarding the classification algorithm.

Moreover, in over 80% of the transactions, the classification was highly decisive (the score difference on the shekel and dollar prices was greater than or equal to one). In Section 7, we examine robustness of the results to the stricter criteria of the classification algorithm.

Figure 1 shows the share of shekel-denominated transactions that took place between 1998 and 2012 according to our classification algorithm. It follows that the currency substitution process in the housing market exhibits three major phases. In the first phase (January 1998–March 2007), the share of shekel-denominated transactions fluctuated around the 15%–40% level, with a moderate upward trend; in the second phase (April 2007–March 2008), the fluctuating share of shekel-denominated transactions climbed from about 45% and crossed the 95% threshold for the first time; and in the third phase (April 2008–September 2012), the share of shekel-denominated transactions maintained its 95% and over dominance. In the micro-analysis below, we thus focus on the period from January 1998 to March 2008 (the currency substitution period).

Table 3 provides summary statistics of housing unit attributes stratified by shekel- and dollar-denominated transactions over the period January 1998 through March 2008. It follows that shekel- and dollar-denominated transactions exhibit highly similar characteristics. Specifically, the average shekel-denominated transaction includes a 906-square-foot, 3.53-room unit, located on the 2.6^{th} floor in a 21-year-old structure (respective standard deviations are 345, 0.13, 16.6, and 2.68), while the average dollar-denominated transaction is an 867-square-foot, 3.42-room unit, located on the 2.3^{rd} floor in a 27-year-old structure (respective standard deviations are 358, 0.09, 16.0, and 2.23). Furthermore, the distribution of transaction share across unit types

(condominium, duplex, detached, etc.—see *Type*1–*Type*8) and locations is similar. Note that despite the similarity in the typical attributes as indicated by Table 3, in the analysis below we control for variation in the attributes across housing units.

METHOD

We now test for asymmetric effects of depreciation and appreciation in the nominal exchange rate on shekel and dollar closing prices. Specifically, we test whether the implied transaction-based exchange rate (i.e., the ratio of shekel transaction price to dollar transaction price—see details below), compared to the nominal exchange rate, is greater (lower) under a dollar depreciation (appreciation) process. Consider the following model consisting of estimated structural Equations (1)–(3):

(1) $P_{i,t}^{shekel} = \alpha_{0t} + \vec{\alpha}_{1t} CHARACTERISTICS_{i,t} + \varepsilon_{1i,t}$ for all $i \in \{S\}$ and t,

(2) $P_{i,t}^{dollar} = \beta_{0t} + \vec{\beta}_{1t} CHARACTERISTICS_{i,t} + \varepsilon_{2i,t}$ for all $i \in \{D\}$ and t,

and

(3) $\widehat{EX}_{i,t} = \gamma_0 + \gamma_1 EX_t + \gamma_2^- \Delta EX_t^- + \gamma_2^+ \Delta EX_t^+ + \varepsilon_{3i,t}$ for all i,

where

(4) $\hat{P}_{i,t}^{shekel} = \hat{\alpha}_{0t} + \hat{\alpha}_{1t} CHARACTERISTICS_{i,t}$ for all $i \in \{D\}$ and t,

(5) $\hat{P}_{i,t}^{dollar} = \hat{\beta}_{0t} + \hat{\beta}_{1t} CHARACTERISTICS_{i,t}$ for all $i \in \{S\}$ and t,

(6) $$\widehat{EX}_{i,t} = \begin{cases} \ln\left(P_{i,t}^{shekel} / \hat{P}_{i,t}^{dollar}\right), & i \in \{S\}, \\ \ln\left(\hat{P}_{i,t}^{shekel} / P_{i,t}^{dollar}\right), & i \in \{D\}, \end{cases}$$

and where $P_{i,t}^{shekel}$ in Equation (1) is the recorded shekel price per square foot of asset i transacted at time (month) t, where i belongs to the set of shekel-denominated transactions, i.e., $i \in \{S\}$; and $P_{i,t}^{dollar}$ in Equation (2) is the recorded *dollar* price per

square foot of asset *i* transacted at time *t*, where *i* belongs to the set of dollar-denominated transactions, i.e., $i \in \{D\}$. ($P_{i,t}^{shekel}$ and $P_{i,t}^{dollar}$ thus refer to assets in non-overlapping sets $\{S\}$ and $\{D\}$, respectively.) Also, *CHARACTERISTICS* in Equations (1) and (2) is a matrix of asset physical-locational attributes—including the city where the dwelling unit is located, the property's area in square feet, number of rooms, the floor on which the property is located in the building, the age of the property, and the structure type. Finally, α_{0t} (β_{0t}) is an estimated parameter, $\vec{\alpha}_{1t}$ ($\vec{\beta}_{1t}$) is an estimated vector of parameters, and $\varepsilon_{1i,t}$ ($\varepsilon_{2i,t}$) is a random disturbance term in Equation (1) ([2]). Equations (1) and (2) are thus two hedonic price equations, one for $i \in \{D\}$ and the other for $i \in \{S\}$, estimated monthly over the period January 1998 through March 2008; hence, they comprise the total of 123 estimations of each of the Equations (1) and (2).[13]

Accordingly, the variable $\hat{P}_{i,t}^{shekel}$ in (4) is the projected quality-adjusted shekel price per square foot of asset *i*, $i \in \{D\}$, based on the estimated parameters in Equation (1); and, similarly, $\hat{P}_{i,t}^{dollar}$ in (5) is the projected quality-adjusted dollar price of asset *i*, $i \in \{S\}$, based on the estimated parameters in Equation (2). In other words, by substituting the characteristics of every *dollar*- (*shekel*-) denominated asset into Equation (4) ([5]), we produce a hypothetical *shekel* (*dollar*) price for that asset had the transaction originally been denominated in *shekels* (*dollars*). Hence, $P_{i,t}^{shekel}/\hat{P}_{i,t}^{dollar}$ in (6) is the ratio of the actual shekel price of asset *i*, $i \in \{S\}$, over its projected dollar price, had it been originally dollar-denominated. Similarly, $\hat{P}_{i,t}^{shekel}/P_{i,t}^{dollar}$ is the ratio of the

[13] Consistent with the dynamics of the currency substitution process presented in Figure 1, the estimation of Equations (1) and (2) ceases with the effective completion of the currency substitution in March 2008. Following that date, the number of monthly dollar-denominated transactions is insufficient to allow the estimation of Equation (2). Notably, moreover, the estimation outcomes are robust to alternative model designs of Equations (1) and (2), including logarithmic transformation of left-hand-side and/or right-hand-side variables as well as measuring price in absolute or per square footage terms. Results obtained from these variations are not presented here and are available on request.

projected shekel price of i, $i \in \{D\}$, had it been shekel-denominated, over its actual dollar price; and ln(·) in (6) is a logarithmic operator.

Correspondingly, we refer to $\widehat{EX}_{i,t}$ on the left-hand side of (6) and (3) (computed by the log of $P_{i,t}^{shekel}/\hat{P}_{i,t}^{dollar}$ and $\hat{P}_{i,t}^{shekel}/P_{i,t}^{dollar}$) as the log of the *implied transaction-based exchange rate* arising from shekel- and dollar-denominated transactions. Also, EX_t on the right-hand side of (3) is the log of the time *t nominal* shekel-dollar exchange rate; that is, the nominal shekel value of one dollar at time *t*. The variables ΔEX_t^- and ΔEX_t^+ on the right-hand side of (3) equal $EX_t - EX_{t-1}$ and apply when $EX_t - EX_{t-1} < 0$ and $EX_t - EX_{t-1} > 0$, respectively. That is, ΔEX_t^- and ΔEX_t^+ denote the rate of dollar depreciation and appreciation (in nominal shekel terms), respectively. Finally, the estimated parameters γ_2^- and γ_2^+ apply when $EX_t - EX_{t-1} < 0$ and $EX_t - EX_{t-1} > 0$, respectively; γ_0 and γ_1 are estimated parameters; and $\varepsilon_{3i,t}$ is a random disturbance term.[14]

Equation (3) allows us to test for asymmetric effects of depreciation and appreciation in the nominal exchange rate on the implied transaction-based exchange rate. The null hypothesis is that in the absence of a systematic seller/buyer strategic behavior in the choice of the currency of the transaction (in the spirit of Cases 1 and 2 in Section 2 above), the implied transaction-based exchange rate replicates the nominal exchange

[14] We formulate Equation (3) in log terms in order to avoid sensitivity of changes in the exchange rate to exchange rate absolute levels. Nevertheless, our outcomes are robust to the estimation of an equivalent linear model (not presented here but available on request). Also, note that in the way Equation (3) is specified, there is no reason to expect that collinearity would persist among the right-hand-side variables, as EX_t is not a linear combination of ΔEX^- and ΔEX^+. In fact, the correlation matrix shows a maximal Pearson correlation of 0.398 between ΔEX^- and ΔEX^+, and the mean variance inflation factor (VIF) is found to be low (1.16, with a maximum of 1.24). Moreover, the outcomes from the estimation of Equation (3) are robust to the omission of ΔEX^+ (again, these outcomes are not presented but are available on request).

rate (i.e., $\widehat{EX}_{i,t}$ be equal to EX_t and thus $\gamma_1 = 1$, $\gamma_2^- = 0$, and $\gamma_2^+ = 0$). Instead, $\gamma_1 = 1$, while $\gamma_2^- \neq 0$ and $\gamma_2^+ \neq 0$ indicate a discrepancy between the transaction-based and the nominal exchange rates under nominal exchange rate fluctuations. In particular, $\gamma_1 = 1$, $\gamma_2^- < 0$, and $\gamma_2^+ = 0$ ($\gamma_1 = 1$, $\gamma_2^- = 0$ and $\gamma_2^+ < 0$) indicate that shekel transactions, compared to dollar ones, associate with a greater (lower) closing price under a dollar depreciation (appreciation) process. As argued in Case 1 (2) in Section 2 above, the latter hypothesis is consistent with employing past and current exchange rates in one's favor. Specifically, $\gamma_1 = 1$, $\gamma_2^- < 0$, and $\gamma_2^+ = 0$ is consistent with a situation under the currency substitution period in which sellers exploit their power in the negotiation to avoid the decreased shekel price under dollar depreciation by opting for the pre-depreciation shekel price, while benefiting from the increased shekel price under dollar appreciation by opting for the dollar price—thus encouraging an upward ratchet price mechanism.[15]

RESULTS

Figure 2 compares between the average (across transactions in month *t*) nominal exchange rate and implied transaction-based exchange rate of quality–adjusted assets that follows from the estimation of Equations (1) and (2) and the computation of (4)–(6) over the 1998 through 2008 period. Recall that under the null hypothesis, one expects that the implied transaction-based exchange rate, $\widehat{EX}_{i,t}$, be equal to the nominal exchange rate, EX_t. It follows, however, from Figure 2 that the former is most often

[15] As our test employs the universe of all housing transactions over the period 1998–2008, no concern exists about a sample selection bias in the dataset. Also, our main focus is on the estimation of γ_2^- and γ_2^+; thus, any concern regarding the prevalence of an unobservable variable that on the one hand correlates with the transaction closing price (e.g., due to unobservable asset or seller attributes) and on the other hand associates with the particular currency (shekel or dollar) denominating the transaction should be dismissed, as it would appear in the estimation of either γ_0 or γ_1.

greater than the latter: in about 70% of the 122 examined months, average monthly $\widehat{EX}_{i,t}$ is greater than average monthly EX_t. This outcome provides a preliminary indication of the increased price for shekel-denominated transactions compared to dollar-denominated ones during the currency substitution period.[16]

Table 4 presents the results of a regression that tests for a price effect of changes in the shekel/dollar exchange rate under currency substitution. Column 1 in the table shows the outcomes obtained from the estimation of Equation (3) for all originally dollar- and shekel-denominated transactions.[17] Empirical findings provide support for an asymmetric price effect of negative and positive shocks in the nominal exchange rate during a currency substitution period. It follows that the coefficient on the nominal shekel/dollar exchange rate, γ_1, is close to 1 (estimated coefficient equals 0.91) and significant at the 1% level, indicating that any change in the nominal shekel/dollar exchange rate, *EX*, is translated into a comparable change in the implied transaction-based exchange rate, $\widehat{EX}$. In addition, however, the coefficient on ΔEX^-, γ_2^-, is -0.76 and significant at the 1% level, implying that a 1% decrease in the nominal shekel/dollar exchange rate associates with a 0.76% increase in the implied transaction-based exchange rate. It thus follows that the net effect of a 1% *decrease* in the nominal exchange rate (jointly via γ_1 and γ_2^-) associates with a 0.15% *decrease* in the implied transaction-based exchange rate. Simultaneously, the coefficient on ΔEX^+, γ_2^+, is equal

[16] While the difference between $\widehat{EX}_{i,t}$ and EX_t seems particularly significant in the post-2006 period, the robustness test presented below shows that our outcomes maintain when we exclude post-2006 observations from the estimation.

[17] The outcomes from the estimation of the hedonic Equations (1) and (2) are not reported but are available upon request. We should note, however, that the average R^2 in the hedonic estimations is equal to 0.54, with maximum and minimum of 0.74 and 0.37, respectively.

to 0.14 (significant at the 1% level). Hence, the net effect of a 1% *increase* in the shekel/dollar exchange rate (jointly via γ_1 and γ_2^+) associates with a 1.05% *increase* in the implied transaction-based exchange rate.[18] Columns 2 and 3 in Table 4 further present results from repeating the estimation of Equation (3) on the sample stratified by $i \in \{S\}$ and $i \in \{D\}$ (shekel- and dollar-denominated transactions, respectively). Evidently, outcomes are similar under these sample specifications.

Our evidence thus shows an asymmetric effect of exchange rate fluctuations on housing prices during currency substitution. Specifically, appreciation (depreciation) in the value of the old currency entails a respective increase (a negligible decrease) in the transaction closing price in terms of the new currency; hence, an upward ratchet price mechanism emerges under currency substitution.[19] Furthermore, our findings are consistent with Case 1 in Section 2 above: namely, the results indicate that the emergence of a dual-currency price during currency substitution allows sellers to exploit fluctuations in the exchange rate between the old and new currency (and to use past exchange rate as an anchor) to attain a greater closing price. In particular, when the dollar depreciates (in shekel terms), sellers attempt to avoid the depreciation in the shekel value of a dollar-denominated transaction by opting for a shekel-denominated transaction, negotiating for the pre-depreciation *shekel* price (which corresponds to the dollar price under the pre-depreciation exchange rate). In contrast, when the dollar

[18] Following the logarithmic specification of Equation (3), the figures 1.05% and 0.15% are obtained from the computation of $0.99^{\gamma_1+\gamma_2^-} - 1$ and $1.01^{\gamma_1+\gamma_2^+} - 1$, respectively.

[19] In substantiating this conclusion, we further rely on the evidence shown above according to which shekel- and dollar-denominated transactions exhibit highly similar typical characteristics (and even more so on the fact that we control for housing attribute variation in Equations (1) and (2)). Moreover, if there were a missing variable, uncontrolled for in our estimation, it would be unlikely to asymmetrically affect price changes under depreciations and appreciations.

appreciates, sellers opt for a dollar-denominated transaction, negotiating for the pre-appreciation *dollar* price (whose shekel value corresponds to the post-appreciation exchange rate).

ROBUSTNESS TESTS

We address the robustness of our findings to three key elements of the sample—namely, a focus on the classification algorithm of dollar- and shekel-denominated transactions, a sample of the implied transaction-based exchange rate, and a sample of specific sub-periods.

To further gauge the sensitivity of the results to the classification of dollar- and shekel-denominated transactions, we impose a stricter criterion upon the algorithm determining the currency in which a transaction was conducted. Tables A1 and A2 in the appendix provide a description and the outcomes from the stricter classification condition.[20] Using the stricter classification condition increases the rate of unclassified transactions to 24%. Figure A1 in the appendix presents the share of shekel-denominated transactions over the 1998–2012 period under the original and the stricter classification conditions. Notably, the two lines are almost identical, indicating that the behavior of the share of shekel-denominated transactions over the examined period is robust to the stricter condition.

In addition, Column 1 in Table 5 presents the outcomes from re-estimating Equation (3) following the stricter classification algorithm. It follows that the estimation

[20] Essentially, the stricter classification condition requires that a score difference of no less than 2 be attained between the dollar and shekel price classification.

outcomes are robust to the stricter algorithm condition. In particular, results indicate that a 1% decrease (increase) in the nominal exchange rate associates (via the coefficients on *EX* and ΔEX^{-}) with a net 0.2% increase in the implied transaction-based exchange rate. In contrast, a 1% increase in the nominal exchange rate associates (via the coefficients on *EX* and ΔEX^{+}) with a net 1.06% increase in the implied transaction-based exchange rate. Hence, an upward ratchet price effect under currency substitution emerges. Columns 2 and 3 in Table 6 show the outcomes from repeating the estimation for the separate sub-samples of shekel- and dollar-denominated transactions ($i \in S$ and $i \in D$, respectively). Similar results are obtained under these specifications.

In another robustness test, we examine the sensitivity of the outcomes to sub-samples that are determined by the level of the implied transaction-based exchange rate, $\widehat{EX}_{it}$. The value of $\widehat{EX}_{it}$ (derived by Equations [1], [2], [4], and [5] and computed in Equation [6]) ranges between -4.88 and 4.95, with an average of 1.43 and a standard deviation of 0.31. In this test, we thus omit observations for which $\widehat{EX}_{it}$ falls in the tails of its distribution and re-estimate Equation (3). Table 6 presents the outcomes from the estimation of (3) for various samples determined by percentile ranges of $\widehat{EX}$. It follows that the findings are robust to these sample specifications. Results indicate that the coefficients on ΔEX^{-} and *EX* are again significant at the 1% level and combined with the coefficient on ΔEX^{+} entail an upward ratchet price effect.

Finally, recall that following Figure 1, the share of shekel-denominated transactions fluctuates over time and that the rate of substitution from dollar- to shekel-denominated transactions is non-monotonic, effectively exhibiting two major sub-phases: from January 1998 to March 2007, during which the share of shekel-denominated

transactions fluctuated within the 15%–40% levels with a moderate upward trend (while at the same time the nominal exchange rate fluctuated within the 3.6–4.9 shekels per one dollar boundaries); and from April 2007 to March 2008, during which the share of shekel-denominated transactions steeply climbed (although non-monotonically) from about 30% to 95% (during which the exchange rate non-monotonically dropped from about 4.3 to 3.5 shekels per dollar). Thus, in another robustness test, we re-estimate Equation (3) for the period January 1998 to March 2007 (excluding the April 2007 to March 2008 period of steep increase in the share of shekel-denominated transactions). Column 1 in Table 7 presents the outcomes obtained from this exercise. It follows that the asymmetric price effect of ΔEX^- and ΔEX^+ maintains under this specification (although its magnitude somewhat moderates). Specifically, it follows from the coefficients on EX, ΔEX^-, and ΔEX^+ that a 1% increase (decrease) in the nominal exchange rate associates with a net 1.06% (0.62%) increase (decrease) in the implied transaction-based exchange rate. As seen from Columns 2 and 3 in Table 8, this asymmetric effect maintains when Equation (3) is separately estimated for $i \in S$ and $i \in D$, respectively.

Macro-Level Analysis

METHOD

In this section we conduct a macro-level test of the asymmetric price effect that associates with nominal exchange rate fluctuations under currency substitution. Consider the following dynamic relationship between the housing price index and the exchange rate:

(7) $$HPI_t = \theta_0' + \sum_{j=1}^{J} \theta_{1,j}' HPI_{t-j} + \sum_{k=0}^{K} \theta_{2,k}' EX_{t-k} + \vec{\theta}_4' CONTROL_t + \varepsilon_{4t},$$

where the log of the housing price index, *HPI*, is an autoregressive process that depends on a distributed lag of current and past values of the log of the shekel-dollar exchange rate, *EX*. Also, $CONTROL_t$ on the right-hand side of (7) is a vector of macroeconomic control variables that may correlate with *HPI*, including the log-difference in the consumer price index (excluding housing) (ΔCPI), level-change in the yield on the one-year shekel treasury bill ($\Delta TBILL$), level-change in the yield difference on the one-year (non-indexed) shekel and dollar treasury bills ($\Delta BILLDIF$), level-change in the mortgage rate ($\Delta MORTGAGE$), level-change in unemployment rate ($\Delta UNEMPLOYMENT$), log-difference in average wage ($\Delta WAGE$), log-difference in the cost of construction index (ΔCCI), log of housing construction completions index (*COMPLETIONS*), and log-difference of population size (ΔPOP).[21]

A preliminary examination of the *HPI* and *EX* series reveals that we cannot reject the presence of a unit root in both the housing price index and the exchange rate series (MacKinnon approximate *p*-values equal 0.483 and 0.659, respectively). We therefore replace *HPI* and *EX* in (7) with their first difference terms, ΔHPI and ΔEX, respectively.[22] Furthermore, in order to allow for an asymmetric response of the housing price index to positive and negative shocks in the exchange rate, we generalize and estimate the model in (7) (in the spirit of Bachmeier and Griffin [2002]) as follows:

[21] We use log-differences in the control variables in cases where the assumption on the stationarity of the series is rejected.

[22] However, we further reject the co-integration hypothesis between *HPI* and *EX* (Johansen co-integration test results generate a trace statistic equal to 12.78 compared with a 1% [5%] critical value of 20.04 [15.41]).

(8)

$$\Delta HPI_t = \theta_0 + \sum_{j=1}^{2} \theta_{1,i}\, \Delta HPI_{t-j} + \sum_{k=0}^{2} \theta_{2,k}^{+}\, \Delta EX_{t-k}^{+} + \sum_{k=0}^{2} \theta_{2,k}^{-}\, \Delta EX_{t-k}^{-} + \vec{\theta}_3 CONTROL + \varepsilon_{5t},$$

where $\theta_{2,k}^{+}$ and ΔEX_{t-k}^{+}, ($\theta_{2,k}^{-}$ and ΔEX_{t-k}^{-}) apply when $\Delta EX_t > 0$ ($\Delta EX_t < 0$); and where lags *j* and *k* are chosen to equal 2 based on the Schwarz's Bayesian information criterion.[23]

RESULTS

As the currency substitution phase was completed in March 2008 (see Figure 1 once again), Column 1 in Table 8 reports the results from estimating Equation (8) over the January 1998 to March 2008 period. Figures 3A and 3B further present the estimated impulse response that follows from the estimation of (8) for a positive and negative shock in the exchange rate, respectively. The findings provide additional support for the prevalence of an upward ratchet price mechanism under the currency substitution process. The parameter estimates for the model suggest an instantaneous price response that follows a positive shock in the shekel-dollar exchange rate (the estimated coefficient on ΔEX_t^{+} is equal to 0.357, significant at the 1% level). Moreover, it follows from Figure 3A that a positive one-unit (i.e., 1%) shock in *EX* significantly increases *HPI* by about 0.48 units (0.48%) and that this effect, *ceteris paribus*, continues in the long run. In contrast, a negative shock in the exchange rate not only carries a smaller

[23] Results (not presented here but available on request) are robust to estimating Equation (8), where *j* and *k* equal either 1 or 3. Also, we estimate Equation (8) when the macroeconomic controls are lagged (with 1-, 3-, 6-, and 12-month lags)—results are further robust to these specifications.

instantaneous price effect (the estimated coefficient on ΔEX_t^- is equal to 0.265, significant at the 1% level), but also, as shown by the impulse response function in Figure 3B, the marginal short-term effect on *HPI* quickly vanishes (and becomes statistically insignificant). Hence, consistent with the micro-level results, the macro-level analysis suggests an asymmetric response of housing prices to exchange rate fluctuations during the currency substitution period.[24]

Based on the estimation of Equation (8) and given the fluctuations of the shekel/dollar exchange rate during the currency substitution period (January 1998–March 2008), we compute the total net price effect of the asymmetric response of the housing price index to exchange rate fluctuations. Figure 4 shows the time-varying level of the housing price index over the period January 1998 through March 2008 compared to its hypothetical level had (*a*) the effect of dollar *depreciation* been identical to the estimated effect of dollar *appreciation* (i.e., had a positive and negative 1% change in *EX* symmetrically associated with a 0.45% positive and negative long-run change in *HPI* as shown in Figure 3A); (*b*) the effect of dollar *appreciation* been identical to the estimated effect of dollar *depreciation* (i.e., a symmetric, no long-run response of *HPI* to changes in *EX* as shown in Figure 3B). It follows that, under both approaches, the asymmetric association between *HPI* and *EX* during the currency substitution process

[24] With respect to the control variables, results (not presented here but available on request) further demonstrate that, as expected, the yield on the one-year shekel treasury bill inversely correlates with the change in housing prices (the coefficient equals -0.01, significant at the 5% level), and the change in unemployment rate positively correlates with housing prices (the coefficient equals 0.02, significant at the 5% level). Also, we repeat the estimation of Equation (8), stratifying the data by regions: Tel Aviv area (including surrounding towns) versus the rest of the country. Results of the impulse response function, however, qualitatively maintain: a positive and negative 1% shock in *EX* associate with a long-run 0.74% price increase (significant at the 5% level) and an insignificant price effect, respectively, for the Tel Aviv area. The equivalent results for the out-of-Tel Aviv-area price index are a 0.55% increase (significant at the 10% level) and insignificant effect for a positive and negative 1% shock in *EX*, respectively (outcomes from these estimations are not reported but are available on request). It thus follows that, while the detected price effect maintains across regions, it is somewhat more salient in the Tel Aviv area, which might be explained by Tel Aviv being the major central business district of Israel.

has prevented an average annual decrease in the housing price index of about 2.3% over the 1998–2008 period.

ROBUSTNESS TEST

Consistent with the micro-level robustness test, we address the robustness of our macro-level findings to the sample of specific sub-periods. Specifically, we re-estimate Equation (8) for the period January 1998 through March 2007 (thus excluding the April 2007 through March 2008 period of steep increase in the share of shekel-denominated transactions—see, once again, Figure 1 and micro-level results in Table 7). Column 2 in Table 8 presents the outcomes obtained from the estimation of Equation (8) over the period January 1998 through March 2007. Figures 5A and 5B further present the estimated impulse response of *HPI* that follows for a positive and negative shock in the exchange rate, respectively. It follows that the results are robust to this sample specification. Specifically, we cannot reject the hypothesis that the coefficients on ΔEX_{t-k}^{+} and ΔEX_{t-k}^{-} for all k=0,1,2 are statistically equal to their obtained estimates for the period January 1998 through March 2008. Moreover, the impulse response function that follows from Figures 5A and 5B indicates that the long-term effect of a positive 1% shock in *EX* significantly increases *HPI* by about 0.5%, whereas a negative shock in the exchange rate carries a statistically insignificant long-term effect.

DOES THE RATCHET PRICE MECHANISM ASSOCIATE WITH SELLER'S/BUYER'S MARKET?

The detected upward ratchet price effect indicates that in the bargaining between the seller and the buyer, the former tended to dominate by exploiting the dual-currency price in her favor. A question that immediately arises, however, is whether the upward ratchet price mechanism is an effect of the examined period being specifically

characterized by a seller's market. In other words, would the reverse (namely, a downward ratchet price pattern) be observed if our data were associated with a buyer's market?

We therefore test whether our result on the upward ratchet price mechanism is driven by the specific examined period being characterized as a seller's market. A number of empirical studies find a positive correlation between housing prices and transaction volume [see, e.g., Stein (1995) and Arbel *et al*. (2009)]. We thus assess the buyer/seller domination of the market by the periodic transaction volume—where, consistent with previous research, we assume that a greater (lesser) number of transactions associates with the period being characterized as a seller's (buyer's) market.

Figure 6 presents the transaction volume and the nominal and real housing price index over the examined currency substitution period, January 1998–March 2008. It follows not only that real prices experienced an overall *decline* of about 20%, transaction volume fluctuated with no clear trend over a large share of the examined period (see 2001–2007), and, further, did not exhibit a positive correlation with prices (Pearson correlation equals -0.42). This evidence provides a preliminary indication that the detected *upward* ratchet price is independent of the period being specifically characterized as a seller's market.

However, to further gauge the possible association between transaction volume and the asymmetric price effect of exchange rate fluctuations, we re-estimate Equation (8), where we now interact the positive and negative shocks in the exchange rate with the

number of transactions in period *t*. Consider the following modification of Equation (8):

(9)

$$\Delta HPI_t = \theta_0 + \sum_{j=1}^{2} \theta_{1,i}\, \Delta HPI_{t-j} + \sum_{k=0}^{2} \theta_{2,k}^{+}\, \Delta EX_{t-k}^{+} + \sum_{k=0}^{2} \theta_{2,k}^{-}\, \Delta EX_{t-k}^{-} + \sum_{k=0}^{2} \theta_{3,k}^{+}\, \Delta EX_{t-k}^{+} \times TRANS_t + \sum_{k=0}^{2} \theta_{3,k}^{-}\, \Delta EX_{t-k}^{-} \times TRANS_t + \theta_4 TRANS_t + \vec{\theta}_5 CONTROL + \varepsilon_{6t},$$

where $TRANS_t$ is the number of transactions in month *t* (see summary statistics of *TRANS* in Table 2) and all other variables are as described above. Hence, the difference between Equations (8) and (9) includes the control for transaction volume and the interaction terms between transaction volume and the positive and negative shocks in *EX*. Following the estimation of (9), we compute the impulse response function for varying levels of transaction volume.

Figures 7A and 7B show the long-run housing price effect of 1% positive and negative shocks, respectively, generated from the impulse response function that follows from the estimation of Equation (9)—for different levels of transaction volume (we vary the transaction volume from the 10th to the 90th percentiles of the transaction volume distribution in our sample). The results show that, for the 10th (90th) percentile of transaction volume, a positive 1% shock in *EX* entails a significant, long-term 0.42% (0.63%) increase in the housing price index. However, a negative 1% shock in *EX* carries a statistically insignificant effect on housing prices, independent of transaction

volume. Evidence thus indicates that: (*a*) the upward ratchet price effect maintains under both seller's and buyer's markets (as proxied by transaction volume); and (*b*) as anticipated, the upward ratchet price effect is somewhat more salient in a seller's than in a buyer's market.[25]

DOES THE RATCHET PRICE MECHANISM CONTINUE AFTER THE CURRENCY SUBSTITUTION IS COMPLETED?

In this section, we examine whether the detected upward ratchet price effect exhibited during the currency substitution period maintains following the completion of the currency transition process. In order to test for the ratchet price mechanism in the post-currency substitution period, we re-estimate Equation (8) for the period April 2008 through December 2014 (when the share of shekel-denominated transactions exceeded 95% of market transactions—see, once again, Figure 1).

Column 3 in Table 8 presents the results from the estimation of Equation (8) for the post-currency substitution period. It follows that the estimated coefficients on ΔEX^{+}_{t-k} and ΔEX^{-}_{t-k} are insignificant for all k=0,1,2 (with the exception that $\theta^{-}_{2,2}$=0.144, significant at the 10% level). Moreover, Figures 8A and 8B present the impulse response estimate of *HPI* to a positive and negative shock in *EX*, respectively, in the period after currency substitution. It follows that that the long-term housing price index response to either a positive or negative shock in the exchange rate is insignificantly different from zero.[26] Results thus provide evidence for the disappearance of the upward ratchet price mechanism in the post-currency substitution period.

[25] Outcomes obtained from the estimation of (9) are not reported but are available upon request.
[26] While the long-term response of *HPI* to a shock in *EX* is insignificant, it follows from Figure 5B that there is a small *positive* two-period lagged response to a negative shock (significant at the 5% level) that quickly turns insignificant.

Summary and Conclusions

This research provides empirical evidence of the prevalence of an upward ratchet price effect under dual-currency price. The currency substitution process experienced by the Israeli real estate market in the past decade provides a unique opportunity for empirically assessing the effect of a dual-currency price on real prices in a market whose transactions involve substantial and long-term economic consequences. The analysis employs all housing transactions in Israel over the currency substitution period.

Micro- and macro-level findings indicate that over the currency substitution period, sellers exploit the fluctuations in the exchange rate between the old and the new currency to reach a favorable closing price. Specifically, our micro-level test demonstrates that a 1% increase in the shekel/dollar nominal exchange rate associated with about a 1% increase in the exchange rate that is implied by shekel- and dollar-denominated transactions, whereas a 1% decrease in the nominal exchange rate associated with only a 0.15% decrease in the implied transaction-based exchange rate. Furthermore, macro-level analysis shows that while a 1% increase in the shekel/dollar exchange rate associated with a 0.45% increase in the housing price index, a 1% decrease in the shekel/dollar exchange rate associated with a zero net effect on the housing price index. Finally, we show that the detected upward ratchet price mechanism associated with exchange rate fluctuations was independent of the period being characterized by buyer's/seller's market and, moreover, disappeared once the currency substitution process was completed.

Research findings thus provide real-world evidence concerning the micro- and macro-level effect of anchoring heuristic on real prices in a market whose transactions involve substantial, long-term economic consequences. Further, our evidence on the asymmetric price effect indicates that in the bargaining between the seller and the buyer, the former tended to dominate by exploiting the fluctuations in the exchange rate in her favor. Finally, the asymmetric price effect that emerges during currency substitution suggests the important role of public policy measures that are designed to accelerate and truncate the currency substitution phase.

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Table 1: List of Micro-Level Variables, Description, and Summary Statistics over the Period January 1998 through March 2008

Variable	Definition	Avg.	Std.	Min.	Max.
AREA	Floor area (in square feet)	884.9	361.1	215	3229
ROOMS	Number of rooms (including living rooms and bedrooms)	3.47	1.02	1.5	10
AGE	Age of the structure (in years) at the time of the transaction	25.28	16.56	1	90
*TYPE*2	Dummy variable equals 1 if the transacted property is a ground level apartment; 0 otherwise	0.009	0.092	0	1
*TYPE*3	Dummy variable equals 1 if the transacted property is a penthouse; 0 otherwise	0.004	0.063	0	1
*TYPE*4	Dummy variable equals 1 if the transacted property is a duplex apartment; 0 otherwise	0.006	0.077	0	1
*TYPE*5	Dummy variable equals 1 if the transacted property is a townhouse; 0 otherwise	0.010	0.100	0	1
*TYPE*6	Dummy variable equals 1 if the transacted property is a style 1 attached unit; 0 otherwise	0.023	0.150	0	1
*TYPE*7	Dummy variable equals 1 if the transacted property is a style 2 attached unit; 0 otherwise	0.018	0.134	0	1
*TYPE*8	Dummy variable equals 1 if the transacted property is a detached unit; 0 otherwise	0.005	0.073	0	1
EX_t	The natural log of the average (across transactions) monthly nominal shekel/dollar exchange rate	1.455	0.073	1.256	1.597
ΔEX^-	$EX_t - EX_{t-1}$ when $EX_t - EX_{t-1} < 0$	-0.008	0.011	-0.045	0
ΔEX^+	$EX_t - EX_{t-1}$ when $EX_t - EX_{t-1} > 0$	0.007	0.012	0	0.087

Table 2: List of Macro-Level Variables, Description, and Summary Statistics over the Period January 1998 through March 2008

Variable	Definition	Avg.	Std.	Min.	Max.
HPI	Natural log of the monthly housing price index (CBS)	5.244	0.038	5.178	5.328
EX	Natural log of the monthly average (across days) nominal shekel/dollar exchange rate (BOI)	1.453	0.075	1.256	1.597
ΔHPI	$HPI_t - HPI_{t-1}$	-0.0001	0.011	-0.025	0.038
ΔEX	$EX_t - EX_{t-1}$	-0.0002	0.019	-0.045	0.087
ΔPOP	Monthly log-difference in the population (CBS)	0.0017	0.0004	0.0012	0.0027
$\Delta WAGE$	Log-difference of monthly average wages per employee job (CBS)	0.003	0.038	-0.081	0.116
$\Delta TBILL$	Level-change in average monthly yield on the one year treasury bill (BOI)	-0.086	0.450	-1.084	2.264
$\Delta MORTGAGE$	Level-change in average monthly mortgage rate (BOI)	-0.010	0.164	-0.360	0.510
$\Delta BILLDIF$	Level-change in the yield difference on the one-year (non-indexed) shekel and dollar treasury bills (BOI, FRB)	-0.050	0.514	-1.225	2.414
ΔCPI	Log-difference in the monthly consumer price index (excluding housing) (CBS)	0.002	0.005	-0.008	0.026
ΔCCI	Log-difference in the monthly construction cost index (CBS)	0.003	0.007	-0.018	0.028
$\Delta UNEMPLOYMENT$	Level-change in monthly unemployment rate (NII)	-0.008	0.094	-0.258	0.446
COMPLETIONS	Monthly housing construction completions index (CBS)	117	31	61	222
TRANS	Number of monthly transactions	3,684	1,120	1,977	7,040

Notes: Summary statistics refer to the period included in the macro-level estimation: January 1998 to December 2012. The source of each series is in parentheses: CBS is the Israel Central Bureau of

Statistics; BOI is the Bank of Israel; FRB is the Board of Governors of the Federal Reserve System; and NII is the National Insurance Institute of Israel.

Table 3: Summary Statistics of Housing Unit Attributes Stratified by Shekel- and Dollar-Denominated Transactions.

Attribute	Shekel Transactions ($i \in S$)		Dollar Transactions ($i \in D$)	
	Avg.	**Std.**	**Avg.**	**Std.**
AREA	906.0	345.2	866.6	358.2
ROOMS	3.53	0.13	3.42	0.09
AGE	21.36	16.60	26.96	15.98
FLOOR	2.59	2.68	2.31	2.23
*TYPE*1	0.933	0.247	0.926	0.258
*TYPE*2	0.007	0.079	0.007	0.081
*TYPE*3	0.003	0.052	0.003	0.057
*TYPE*4	0.004	0.061	0.006	0.075
*TYPE*5	0.008	0.088	0.011	0.105
*TYPE*6	0.018	0.107	0.020	0.115
*TYPE*7	0.021	0.140	0.018	0.132
*TYPE*8	0.003	0.046	0.005	0.061

Notes: Table 3 presents the averages of the annual mean and standard deviation of housing attributes across all observations i stratified by shekel- and dollar-denominated transactions ($i \in S$ and $i \in D$, respectively) over the period 1998–2008. Notably, the difference in the distribution of the share of shekel- and dollar-denominated transaction across cities is small (not presented here but available on request).

Table 4: Results from the Micro-Level Estimation of Equation (3)

Variable	**For all i**	**For $i \in S$**	**For $i \in D$**
	(1)	(2)	(3)
Constant	0.099***	0.246***	0.068***
	(0.012)	(0.020)	(0.015)
EX	0.912***	0.793***	0.938***
	(0.008)	(0.014)	(0.010)
ΔEX^-	-0.759***	-0.720***	-1.094***
	(0.056)	(0.091)	(0.076)
ΔEX^+	0.138***	0.196**	0.302***
	(0.051)	(0.087)	(0.064)
N	279,630	87,329	192,301
p(F)	0.000	0.000	0.000
R^2	0.045	0.042	0.043

Notes: Table 4 presents the outcomes from the estimation of Equation (3). Standard errors appear in parentheses. One, two, and three asterisks represent significance at the 10%, 5%, and 1% levels, respectively. Results for the complete sample are presented in Column (1) (titled for all *i*); Column (2) provides results for shekel-denominated transactions only (for $i \in S$); and Column (3) provides results for dollar-denominated transactions only (for $i \in D$). Finally, the low R^2 values are expected, as the explanatory variables in Equation (3) do not control for within-period asset-specific characteristics. In this regard, results are robust for using the median value of $\widehat{EX}_t$ for each month in which case R^2=0.90. Finally, all results in the table are robust to the omission of ΔEX^+ from the estimation.

Table 5: Results from the Micro-Level Estimation of Equation (3) under the Stricter Classification Criterion

Variable	**For all i**	**For $i \in S$**	**For $i \in D$**
	(1)	(2)	(3)
Constant	0.208***	0.264***	0.219***
	(0.016)	(0.028)	(0.020)
EX	0.827***	0.781***	0.821***
	(0.011)	(0.019)	(0.014)
ΔEX^-	-1.027***	-0.947***	-1.267***
	(0.071)	(0.121)	(0.095)
ΔEX^+	0.226**	0.154	0.373***
	(0.065)	(0.114)	(0.081)
N	180,835	53,114	127,721
p(F)	0.000	0.000	0.000
R^2	0.033	0.037	0.029

Notes: Table 5 presents the outcomes from the estimation of Equation (3) under the stricter classification criterion. Standard errors appear in parentheses. One, two, and three asterisks represent significance at the 10%, 5%, and 1% levels, respectively. Results for the complete sample are presented in Column (1) (titled $\widehat{EX}_{i,t}$ for all i); Column (2) presents results for shekel-denominated transactions only ($\widehat{EX}_{i,t}$ $i \in S$); and Column (3) presents results for dollar-denominated transactions only ($\widehat{EX}_{i,t}$ $i \in D$). Low R^2 values are expected, as the explanatory variables in Equation (3) do not control for within-period asset-specific characteristics. Finally, all results in the table are robust to the omission of ΔEX^+ from the estimation.

Table 6: Results from the Micro-Level Estimation of Equation (3) for Various Percentile Ranges of the Implied Exchange Rate Variable, $\widehat{EX}_{i,t}$

Variable	**Percentile Ranges**				
	1st-99th	5th-95th	10th-90th	25th-75th	50th (Median)
	(1)	(2)	(3)	(4)	(5)
Constant	0.102***	0.119***	0.133***	0.162***	0.135***
	(0.011)	(0.009)	(0.007)	(0.005)	(0.005)
EX	0.910***	0.900***	0.891***	0.872***	0.889***
	(0.007)	(0.006)	(0.005)	(0.004)	(0.027)
ΔEX^-	-0.735***	-0.718***	-0.705***	-0.700***	-0.721***
	(0.051)	(0.042)	(0.036)	(0.025)	(0.205)
ΔEX^+	0.135**	0.131***	0.131***	0.126***	0.136
	(0.047)	(0.099)	(0.033)	(0.023)	(0.171)
N	274,220	251,838	146,254	139,937	123
p(F)	0.000	0.000	0.000	0.000	0.000
R^2	0.054	0.081	0.116	0.293	0.903

Notes: Table 6 presents the outcomes from the estimation of Equation (3) for various percentile ranges of the implied exchange rate variable, $\widehat{EX}_{i,t}$. Standard errors appear in parentheses. One, two, and three asterisks represent significance at the 10%, 5%, and 1% levels, respectively. Presented results are for the complete sample ($\widehat{EX}_{i,t}$ for all *i*). Columns (1), (2), (3) and (4) present results from the estimation of Equation (3) based only on observations with $\widehat{EX}_{i,t}$ between 1–99 percentiles (for each time period *t*), 5–95 percentiles, 10–90 percentiles, and 25–75 percentiles, respectively. Column (5) presents the estimation outcome where $\widehat{EX}_{i,t}$ in each time period is represented by its median value. Finally, low R^2 values are expected, as the explanatory variables in Equation (3) do not control for within-period asset-specific characteristics (as expected, the value of R^2 increases substantially for the median value estimation in Column [5]). Results in Column (5) are robust for using a Prais-Winsten estimation procedure.

Table 7: Results from Micro-Level Estimation of Equation (3) over the Period January 1998–March 2007

Variable	**For all i**	**For $i \in S$**	**For $i \in D$**
	(1)	(2)	(3)
Constant	0.011	0.038	-0.044***
	(0.014)	(0.027)	(0.016)
EX	0.972***	0.931***	1.016***
	(0.009)	(0.019)	(0.011)
ΔEX^-	-0.352***	-0.407***	-0.384***
	(0.073)	(0.128)	(0.087)
ΔEX^+	0.090	0.205**	0.116*
	0.572	(0.102)	(0.068)
N	232,198	56,271	175,927
p(F)	0.000	0.000	0.000
R^2	0.046	0.045	0.049

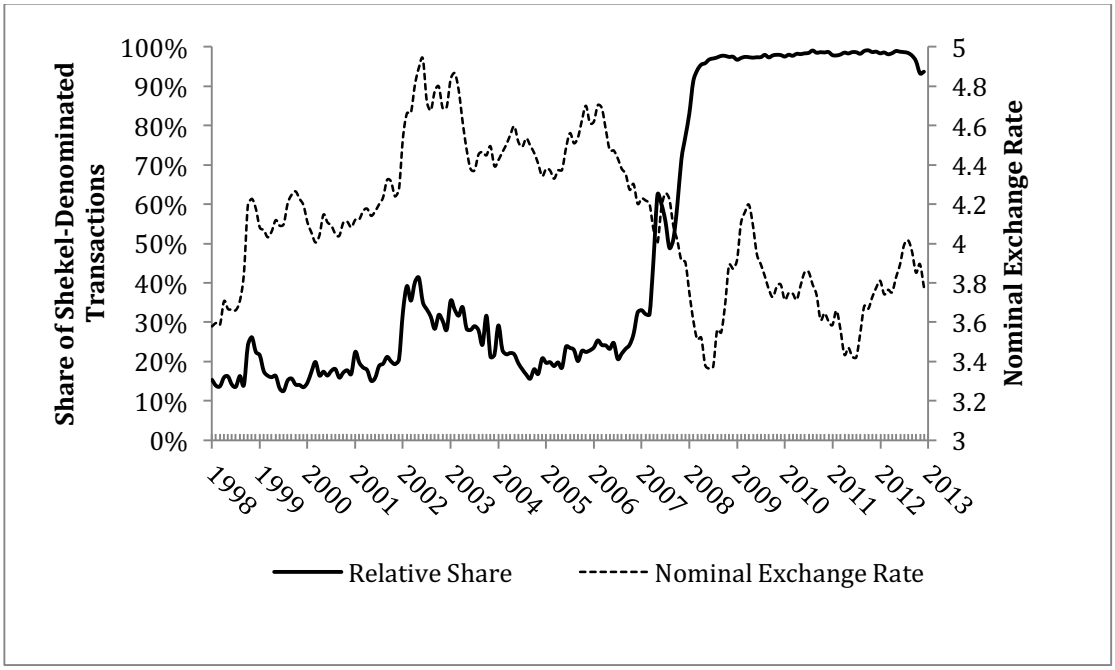
Notes: Table 7 presents the outcomes from the estimation of Equation (3) over the period January 1998 through March 2007. Standard errors appear in parentheses. One, two, and three asterisks represent significance at the 10%, 5%, and 1% levels, respectively. Results for the complete sample are presented in Column (1) (titled for all *i*); Column (2) provides results for shekel-denominated transactions only (for $i \in S$); and Column (3) provides results for dollar-denominated transactions only (for $i \in D$). Finally, low R^2 values are expected, as the explanatory variables in Equation (3) do not control for within-period asset-specific characteristics.

Table 8: Results from Macro-Level Estimation of Equation (8)

	Jan98–March08	Jan98–March07	April08–Dec14
	(1)	(2)	(3)
Constant	0.002 (0.005)	0.002 (0.005)	0.002 (0.005)
ΔHPI_{t-1}	0.434* (0.250)	0.217 (0.291)	0.549*** (0.143)
ΔHPI_{t-2}	-0.200 (0.257)	-0.312 (0.257)	-.112 (0.139)
ΔEX_t^+	0.357*** (0.114)	0.433*** (0.131)	-0.006 (0.059)
ΔEX_{t-1}^+	-0.120 (0.123)	-0.058 (0.134)	-0.010 (0.064)
ΔEX_{t-2}^+	0.120 (0.114)	0.174 (0.118)	0.017 (0.069)
ΔEX_t^-	0.265*** (0.095)	0.370*** (0.108)	-0.085 (0.076)
ΔEX_{t-1}^-	-0.128 (0.091)	-0.0533 (0.105)	-0.108 (0.072)
ΔEX_{t-2}^-	-0.082 (0.091)	-0.019 (0.109)	0.169** (0.082)
Control variables	Included	Included	Included
N p(F) R^2	117 0.0000 0.50	105 0.0000 0.51	79 0.0002 0.48

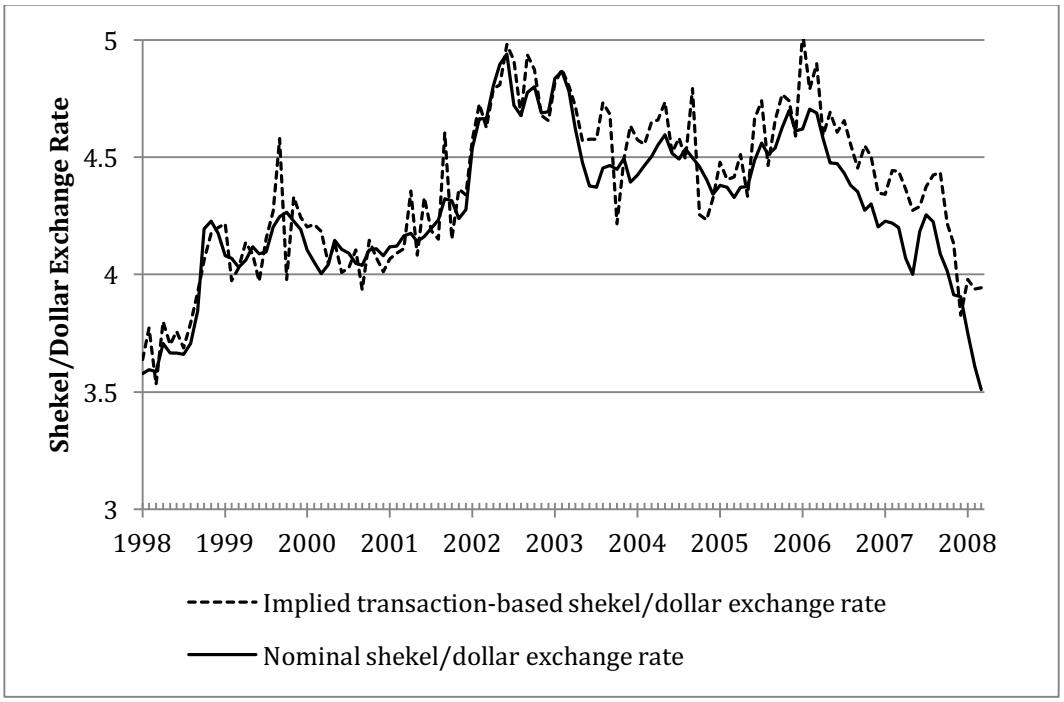
Notes: Table 8 presents the outcomes from the estimation of Equation (8). Standard errors appear in parentheses. One, two, and three asterisks represent significance at the 10%, 5%, and 1% levels, respectively. Control variables include log-difference of the consumer price index (excluding housing) (Δ*CPI*), level-change in the yield on the one-year shekel treasury bill (Δ*TBILL*), level-change in the yield difference on the one-year (non-indexed) shekel and dollar treasury bills (Δ*BILLDIF*), level-change in the mortgage rate (Δ*MORTGAGE*), level-change in unemployment rate (Δ*UNEMPLOYMENT*), log-difference of average wage (Δ*WAGE*), log-difference of the cost of construction index (Δ*CCI*), log-difference of population size (Δ*POP*), and housing construction completions index (*COMPLETIONS*).

Figure 1: The Share of Shekel-Denominated Transactions and Average Nominal Shekel-Dollar Exchange Rate, January 1998–December 2012



Notes: The solid line represents the relative share of shekel-denominated transactions in month *t*, whereas the scattered line represents the absolute level of the average (across days) nominal shekel-dollar exchange rate in month *t*.

Figure 2: Average (Across Transactions in Month *t*) Nominal Shekel-Dollar Exchange Rate and Implied Transaction-Based Exchange Rate of Quality-Adjusted Assets, January 1998–March 2008



Notes: The solid line represents the average (across transactions) nominal shekel-dollar exchange rate (*EX*), whereas the scattered line represents the average (across transactions) implied transaction-based exchange rate, $\widehat{EX}$.

Figure 3A: Response of *HPI* to a 1% Positive Impulse in *EX* During the Currency Substitution Period (January 1998–March 2008)

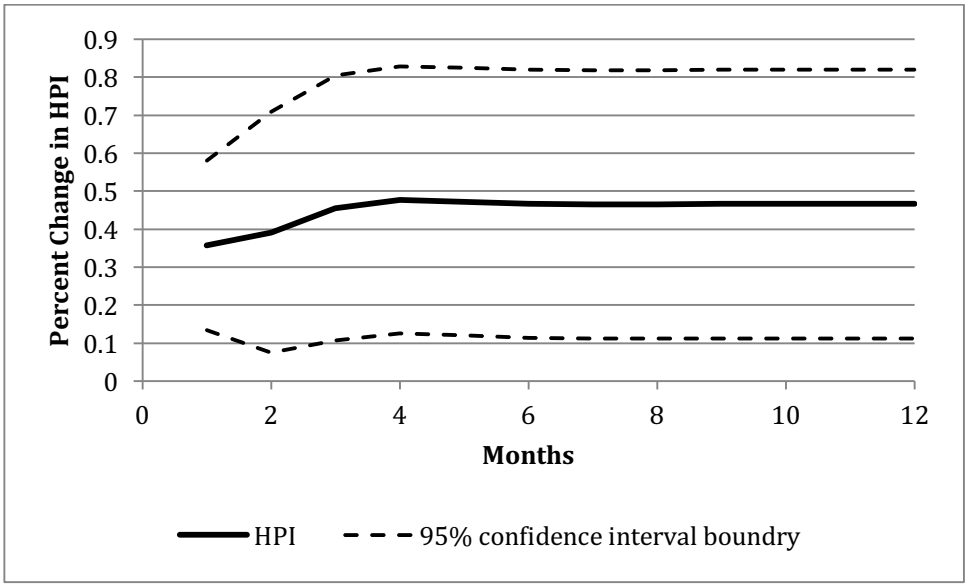


Figure 3B: Response of *HPI* to a 1% Negative Impulse in *EX* During Currency Substitution Period (January 1998–March 2008)

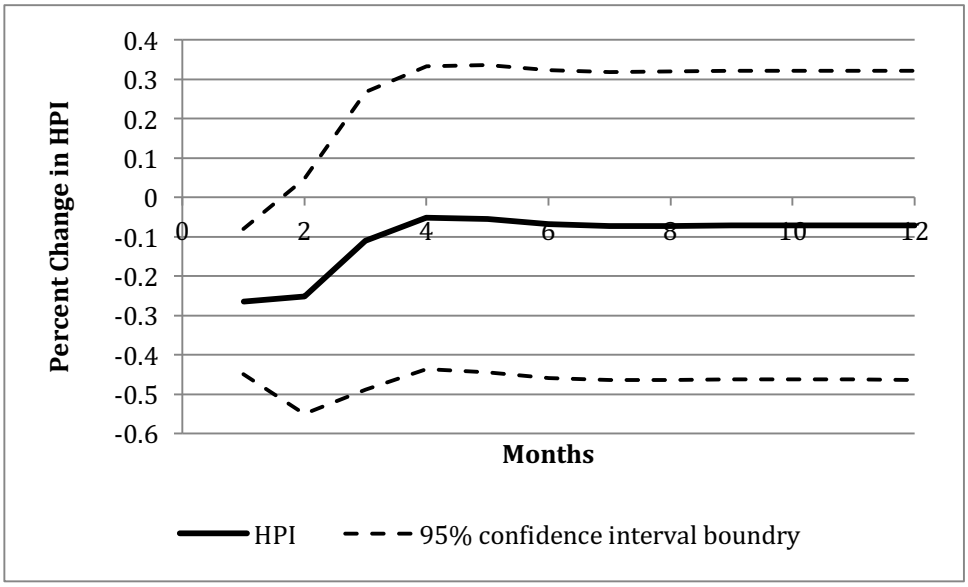


Figure 4: Actual and Hypothetical Levels of the Housing Price Index over the Currency Substitution Period (January 1998–March 2008)

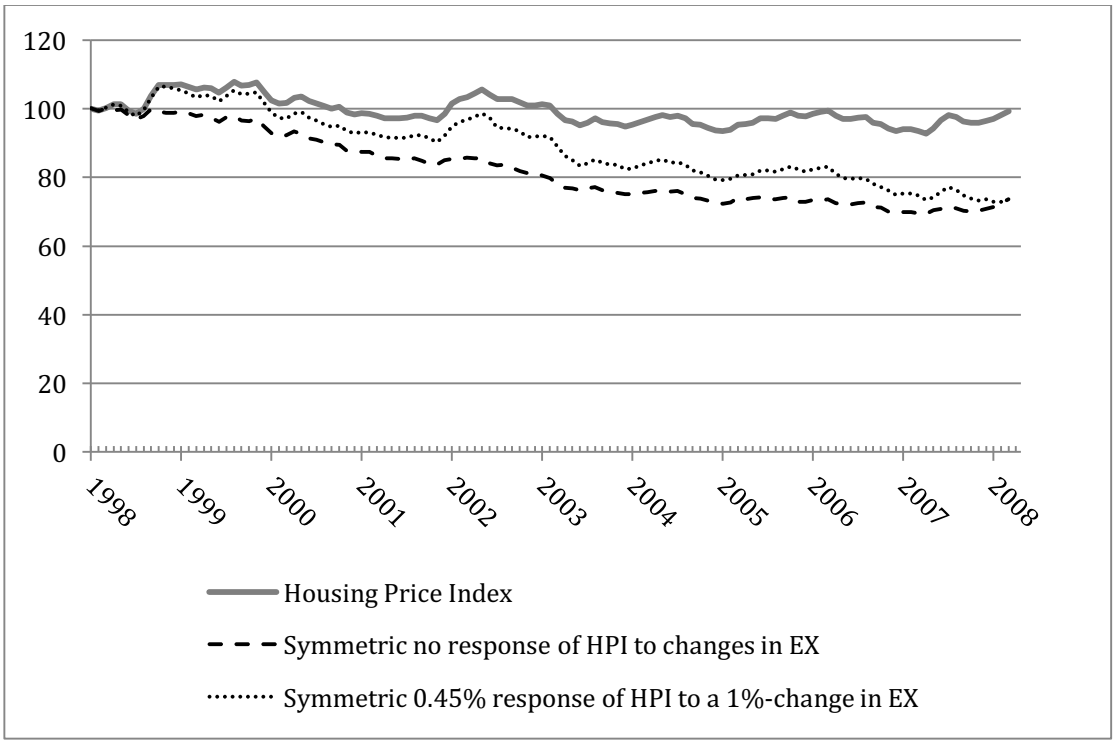


Figure 5A: Response of *HPI* to a 1% Positive Impulse in *EX* over the Period January 1998–March 2007

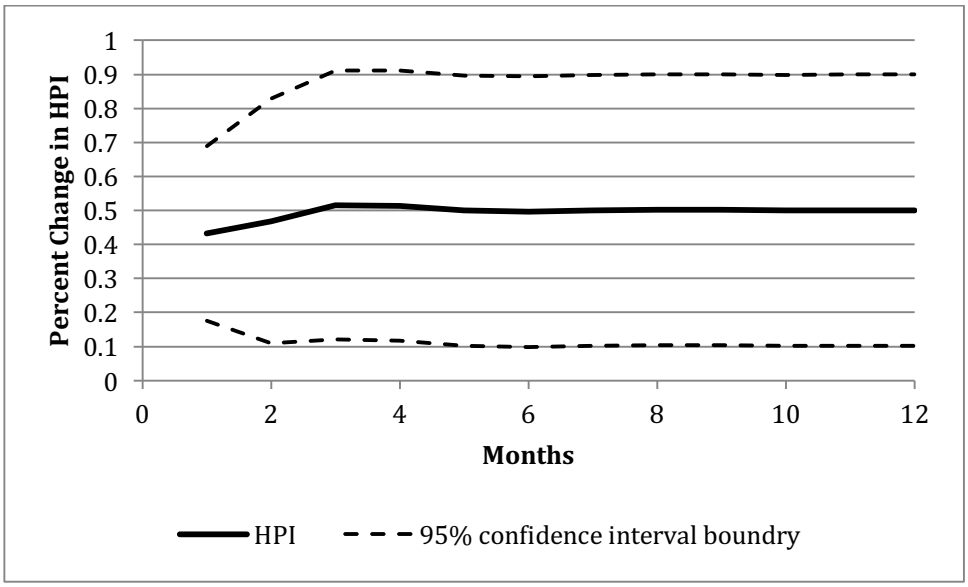


Figure 5B: Response of *HPI* to a 1% Negative Impulse in *EX* over the Period January 1998–March 2007

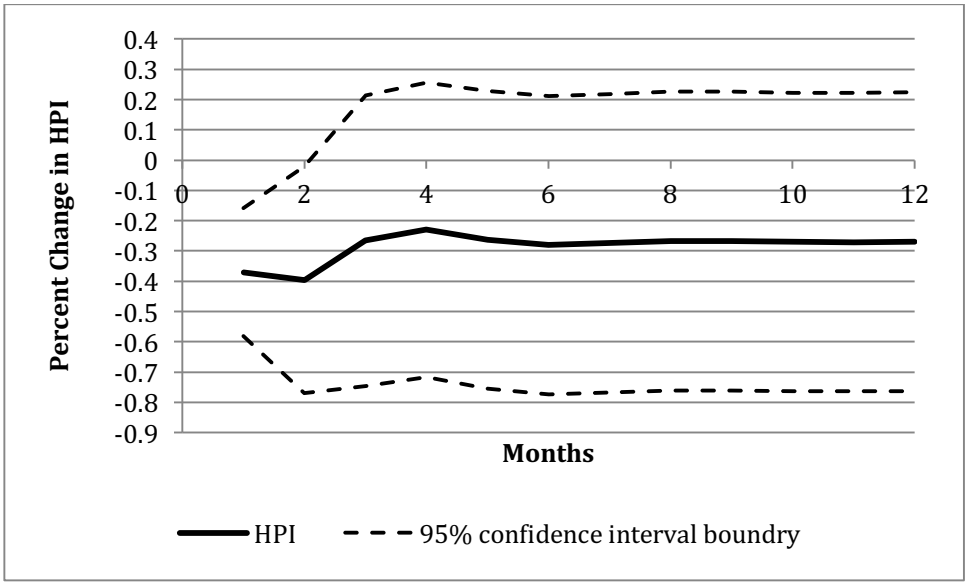


Figure 6: Transaction Volume and Nominal and Real Housing Price Index over the Period January 1998–March 2008

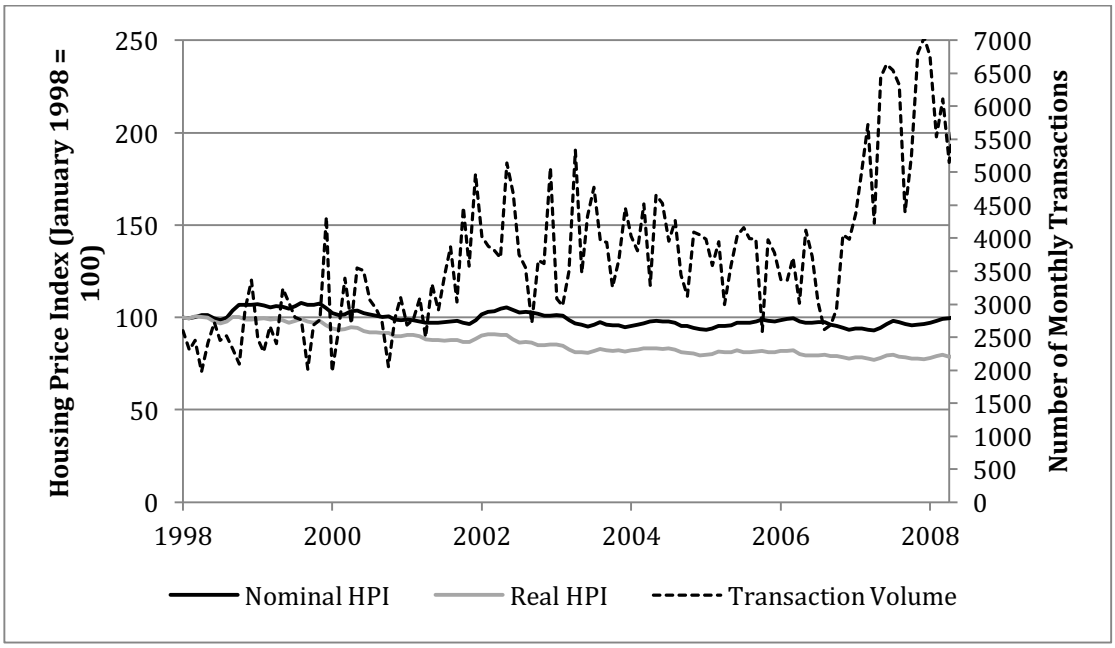


Figure 7A: Long-Run Response of *HPI* to a 1% Positive Impulse in *EX* for different Percentiles of Transaction Volume

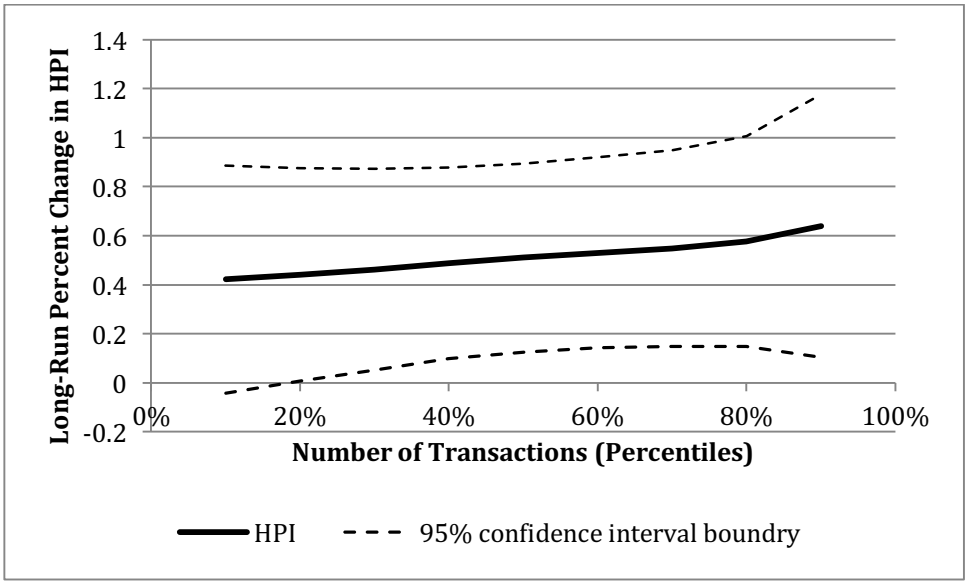


Figure 7B: Long-Run Effect on *HPI* of a 1% Negative Impulse in *EX* for different Percentiles of Transaction Volume (by percentiles)

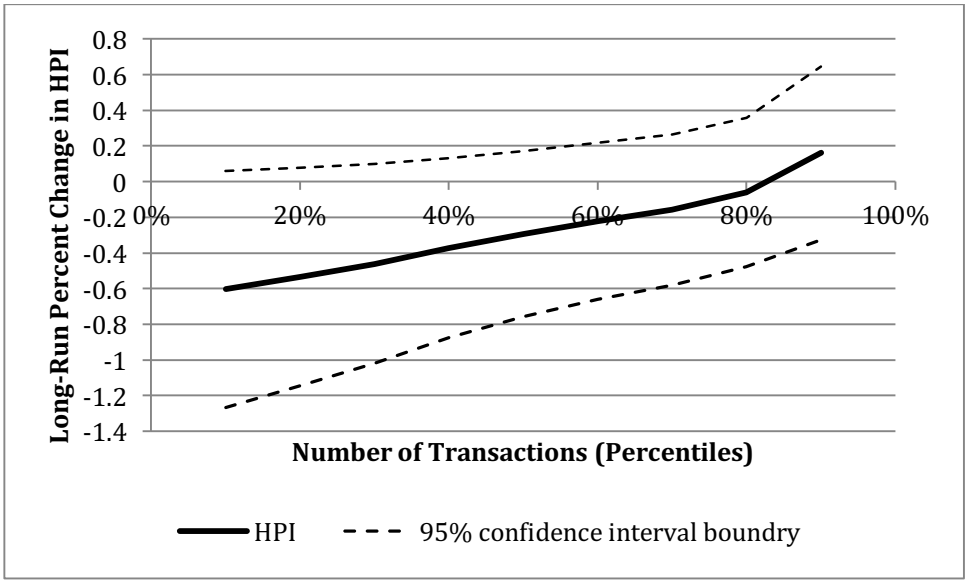


Figure 8A: Response of *HPI* to a 1% Positive Impulse in *EX* During the Post-Currency Substitution Period

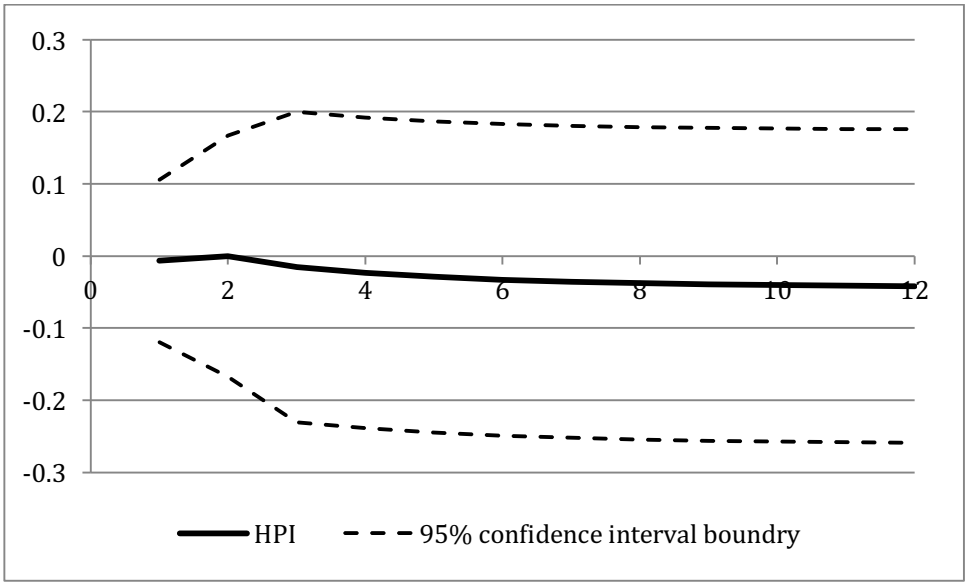
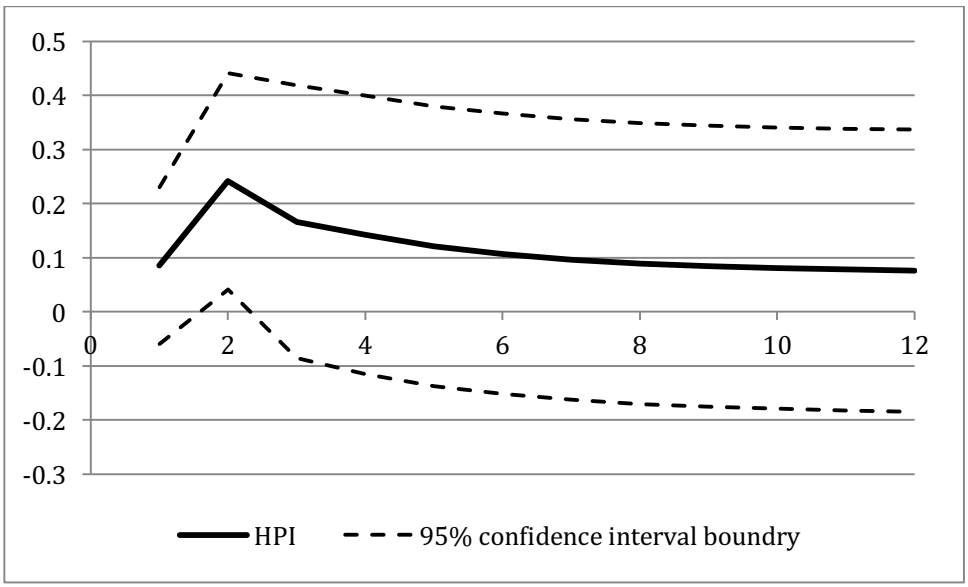


Figure 8B: Response of *HPI* to a 1% Negative Impulse in *EX* During the Post-Currency Substitution Period



Appendix

Table A1: Algorithm for Classifying the Originally Denominated Currency of the Transaction

Last 3 Digits of Price	Example: Price (in Shekels or Dollars)	'Roundness' Score	Share of Recorded Shekel Price	Share of Recorded Dollar Price
QZX	71,843	0	21.9%	49.3%
ZX5	71,845	0.5	6.4%	6.1%
ZX0	71,840	1	14.7%	5.0%
X50	71,850	1.5	2.8%	0.9%
X00	71,800	2	5.3%	0.9%
500	71,500	2.5	1.8%	4.0%
000	72,000	3	45.8%	33.1%
YYY	71,999	3	1.3%	0.7%
Total			**100%**	**100%**

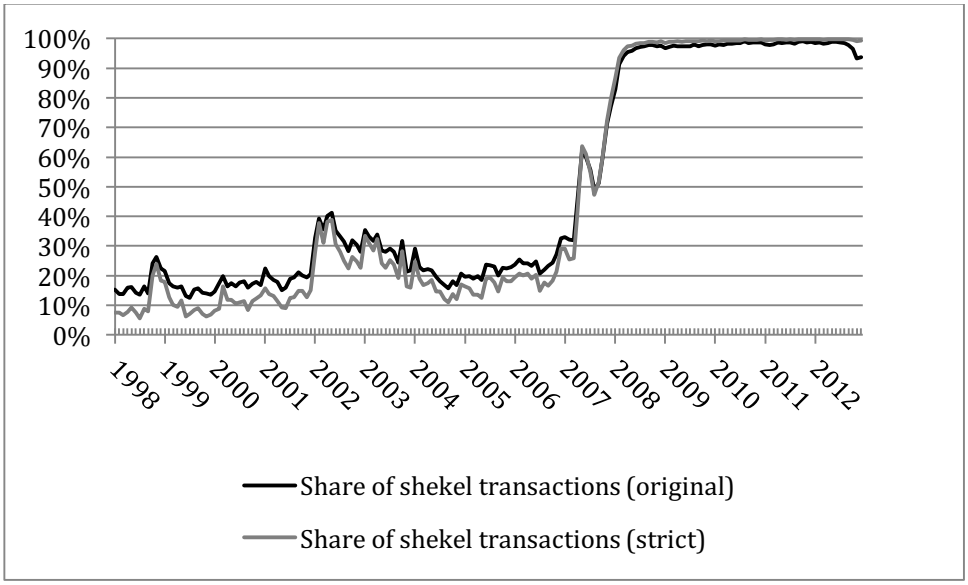
Notes: X represents any digit different from "0" or "5"; Z and Q represent any digit; and Y represents any digit different from "0." The price (either shekel or dollar) that receives a greater "roundness" score is assumed to be the price originally denominated in the transaction. The stricter algorithm requires that the currency that is determined as the one denominating the transaction receives a score of no less than 1.5 greater than the other currency. Percentages in the last two columns are computed over all observations from January 1998 to December 2012.

Table A2: Distribution of the Difference between Dollar and Shekel Price Classification Scores

Difference between Dollar and Shekel Price Classification Scores for Same Transaction	Classification Type		Difference Distribution	
	Original	**Stricter**	**1998-2012**	**1998-2008**
3	Dollar-denominated transactions	Dollar-denominated transactions	11.7%	19.6%
2.5			6.9%	11.5%
2			11.8%	19.7%
1.5		Unclassified	2.6%	4.3%
1			4.1%	6.4%
0.5			1.5%	2.1%
0	Unclassified		7.6%	9.0%
-0.5	Shekel-denominated transactions		1.7%	2.5%
-1			3.3%	4.7%
-1.5			1.5%	1.6%
-2		Shekel-denominated transactions	5.4%	3.7%
-2.5			5.6%	2.5%
-3			36.5%	12.4%
Total			**100%**	**100%**

Notes: In each transaction, the difference is calculated as the 'roundness' score of the reported dollar price minus the 'roundness' score of the reported shekel price. The scores are calculated as presented in Table A1.

Figure A1: The Share of Shekel Denominated Transactions 1998–2012, Original Versus Stricter Classification Conditions



Notes: The solid line represents the relative share of shekel-denominated transaction in month *t*, whereas the scattered line represents the absolute level of the average (across days) nominal shekel-dollar exchange rate in month *t*.