Estimating Price Rigidities in the Russian Real Estate Markets

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Abstract

Behavior of apartment prices in the Russian cities following the ruble devaluation in August 1998 differed markedly in different cities. In cities, where prices were denominated in dollars, they fell slowly over time. In cities, where apartments were priced in rubles, the dollar-equivalents fell rapidly with the exchange rate, stayed low for two to three years, and then recovered rapidly when economy picked up. Such behavior is found to be consistent with a sticky-price model with backward-looking agents. Sticky information model finds less support. Finally, such behavior of prices is not consistent with forward-looking agents or flexible prices.

1 Introduction

The Russian financial crisis of August 1998, as any other major disruption of economic activity, has produced a number of observations interesting to academic economists. One such striking observation is behaviour of prices for apartments in different Russian cities. As noted first by Gennadiy Sternik from the Russian Guild of Realtors, prices of apartments in cities, where they are quoted in rubles, the local currency, have behaved quite differently from the prices in the cities, where the denomination is in American dollars.[1] Specifically, in the "dollar" cities, prices fell quite slowly and recovered slowly when the economy started to recover a couple of years later. In the ruble cities, by contrast, the dollar-equivalents of the prices fell dramatically on impact, in September of 1998, together with the exchange rate, and stayed lower than in the dollar cities throughout the period of low income.

This paper uses this observation as a natural experiment to test different models, which potentially could explain such behavior of prices, and finds that only the model with sticky prices and adaptive expectations is consistent with the data. A model with flexible prices cannot be in line

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[1] Articles by Sternik describing this behavior can be found at http://www.realtymarket.ru

with these observations, because such a model would predict identical behavior of prices in all cities. The model with forward-looking price-setters also does not do well, as it fails, as usual, to replicate the acceleration of inflation of time of high income. Finally, the model with sticky information, advocated recently by Mankiw and Reis (2002a, 2002b), also finds weaker support with the data, although is not outright rejected.

The paper is organized as follows. Section 2 describes the behavior of apartment prices and introduces the reader to the general conditions in the Russian economy in 1998-2001. Then, Section 3 shows a simple sticky-price model with forward-looking and then adaptive expectations and demonstrates that only the adaptive expectations version is consistent with the data. Section 4 builds a model based on sticky information and shows the results of corresponding empirical tests. Section 5 then demonstrates that the flexible model fails as well. Section 6 concludes.

2 Facts and Discussion

In August of 1998, Russia has suffered a disastrous financial crisis, which lead to a double real devaluation of the ruble and a big fall in the real income. Inflation, which was virtually subdued during the period of the "crawling peg" over 1995-1998, spiked up to a monthly 36% in September, totaled 84% in all of 1998, and then slowly fell to about 18% in 2001. The exchange rate, held at about 6.2 rubles per dollar until the devaluation, went to 16 rubles per dollar in September, and then gradually climbed to about 30 rubles per dollar by the end of 2001. Thus, the original devaluation was much stronger than the increase in the price level.

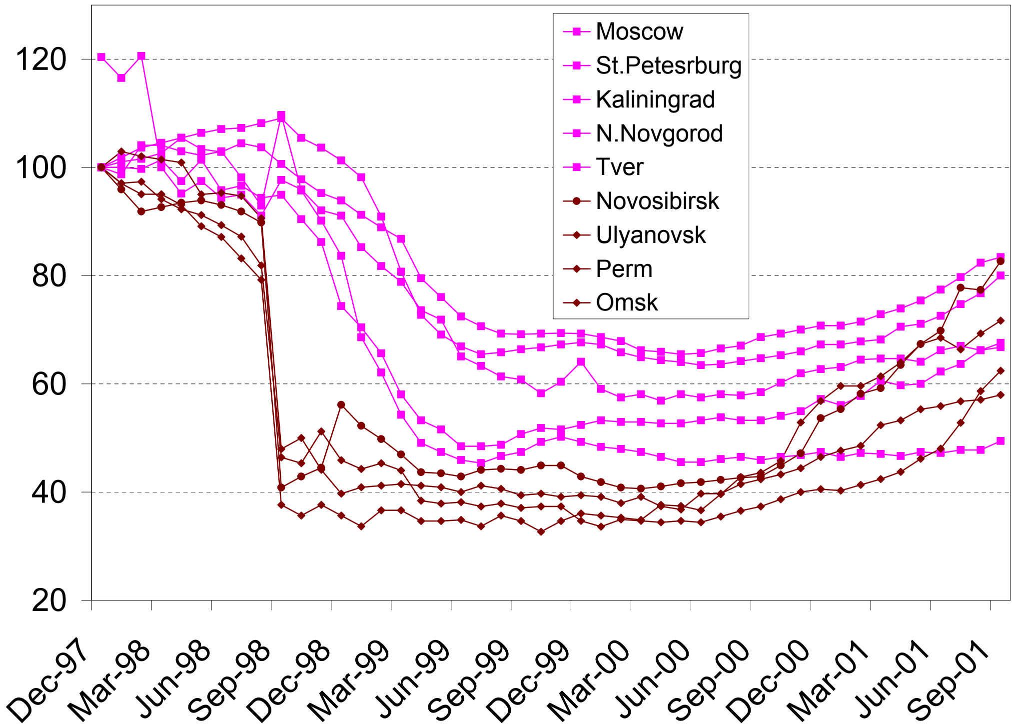
The real income, in turn, fell gradually by about 20%, reaching the trough in the first half of 1999, and then recovering to pre-crisis levels by the end of 2001.

The behavior of apartment prices in 9 Russian cities is shown in Figure 2. These prices represent the dollar equivalents of the averages per square meter on the secondary market, with December 1999 normalized to 100.[2] In Kaliningrad, Nizhniy Novgorod, Moscow, St.Petersburg, and Tver apartment have been priced in dollars, while in Novosibirsk, Omsk, Perm, and Ulyanovsk the pricing has been traditionally done in rubles. This purely nominal difference between the pricing practices appears to have a huge effect on the dynamics. Thus, in the dollar cities, the fall of prices has been much slower and smaller in magnitude than in the ruble cities, giving immediate support to the hypothesis that the prices have been rigid in the currency, in which they are quoted. The dollar prices in the dollar cities have not changed very much on impact, nor did the ruble prices in ruble cities. Instead, the dollar-equivalents of the ruble prices fell immediately simply because the exchange rate grew almost threefold between August and September 1998.

Of course, the distribution of the dollar-pricing and ruble-pricing cities is far from random, which sheds doubt on whether the above observation can be used as a true natural experiment. After all, the dollar cities do seem to be more westernized in general, so they may be subject to different dynamics than the more provincial ruble cities. Thus, the denomination of prices is potentially a

[2] In Russia, it is customary to own apartments, rather than rent them.

Figure 1: Russian cities: behavior of apartment prices



Source: The Russian Guild of Realtors.

highly endogenous variable. However, these fears do not disturb us very much. First of all, the dynamics of income in different cities do not show any variations that can explain different price behavior within those cities. Besides, we do use regional, as well as aggregate incomes in regressions that follow, so income effects are caught. Second, Levina and Zamulin (2002) have shown that an economy or an individual market can be stuck in a dollar-pricing equilibrium after a period of high inflation, and no one would be willing to unilaterally switch to ruble pricing even after inflation is subdued, for fears of deviating far from the competitors' prices with fluctuations of the exchange rate. Thus, we believe that different cities are simply caught in different equilibria after the high inflation of early 1990s, and hence the denomination of prices is no longer as endogenous as may seem.

3 Sticky price models

The sticky price model is based on that of Kimball (1995), which in turn models the price-setting process following Calvo (1983). It is assumed that the sellers adjust their price at a stochastic rate α. Of course, for the secondary apartment markets, the sale of an apartment is a one-time event, and the seller may be keeping the price constant until the apartment is sold; however, she can certainly adjust the price after a while if she observes that the apartment is not selling for the price quoted from the start. For the primary market, apartments are a standard product, so their price is adjusted up and down on regular basis.

We assume that in each period there is an unobservable instantaneous "desired price" $p^{\#}$ (given in logarithm) common to all. This is the price that maximizes profits of firms in the primary market and maximizes utility of sellers on the secondary market, who desire to sell their apartment fast on the one hand, and earn as much money as possible on the other. We do not model this maximization problem explicitly, but rather assume the following standard condition for the desired price:

$$p_t^{\#} = p_t^a + \beta(q_t - \bar{q}) = p_t^a + \beta q_t, \tag{1}$$

where p_t^a is the average apartment price level, q_t is the total demand for apartments at time t, and $\bar{q}$ is the demand at the natural level of total income, here normalized to zero in logarithm. Expression (1) says that the instantaneously optimal price for each apartment relates to the average market price and excess demand. At the time of high demand, a seller would prefer to quote a price somewhat above the average, at the time of low demand - below average. Hence, the parameter β denotes "real price rigidity" in the sense of Ball and Romer (1990): the parameter shows how much the optimal price depends on the real demand as opposed to prices of the competitors.

The second expression of the model is the total demand on the apartment markets. It is assumed that the total demand for apartments is CES in the total income and relative price, and is thus given in logarithmic form by

$$q_t = y_t - \gamma(p_t^a - p_t), \tag{2}$$

where y_t is the total income of the households in the city, while p_t is the overall price level.

The third equation shows the behavior of the apartment price level p_t^a. Since on average each period α sellers adjust their prices, then in each period the change in price level will equal this fraction of price adjusters times the difference between the current price level and the "reset" price b_t - the price set by the seller, who gets a chance to adjust at time t. Thus, inflation in the apartment market is determined by:

$$\Delta p_{t+1}^a = \alpha(b_{t+1} - p_t^a). \tag{3}$$

The change of price is thus the reset price as of the current period less the price level inherited from the previous period.

To close the model and produce testable implications, we need an expression for the reset price b_t. The way this price is determined heavily depends on the type of expectation, which the sellers have. Here we consider two possibilities: forward-looking (rational) expectations, and adaptive expectations. Let us consider both in turn.

3.1 Forward-looking expectations

In case the sellers are rational and forward-looking, they set the price keeping in mind expectations of the future desired prices. A standard result is this literature is that the reset price equals a weighted average of the future desired prices (for example, this result can be obtained from minimizing the present value of future quadratic losses from price non-optimality as in Ball, Mankiw and Romer (1988)):

$$b_t = \alpha \sum_{s=0}^{\infty} (1-\alpha)^s p^{\#}_{t+s}. \tag{4}$$

From here, taking differences, we obtain the following expression for the evolution of the reset price:

$$\Delta b_{t+1} = \alpha (b_{t+1} - p^{\#}_t). \tag{5}$$

Expression (5) allows us to derive a testable equation in terms of observable variables. For that, take the first difference of (3), substitute (5) in, expand $b_{t+1} - p^{\#}_t = b_{t+1} - p^a_t + p^a_t - p^{\#}_t$, and use (3) again to eliminate b_{t+1}. Then, use (1) and (2) to eliminate $p^{\#}_t$ and obtain

$$\Delta \pi^a_{t+1} = -\frac{\alpha^2 \beta}{1-\alpha} y_t + \frac{\alpha^2 \beta \gamma}{1-\alpha} (p^a_t - p_t), \tag{6}$$

where $\pi^a_{t+1} \equiv p^a_{t+1} - p^a_t$. Thus, we obtain results on the change of the inflation rate of the apartment prices. This result reflects that in a sticky-price environment, inflation should be high but decelerating at times of high demand, and, correspondingly, low but rising when demand is weak.

The equation (6) can be tested for each city individually or for all combined. It is important to realize, however, that the nominal variables have to be denominated in the currency, in which the apartments are actually denominated in that city. The only nominal variable in (6) is the change of inflation on the left-hand side, so we make sure that the inflation is take in the right currency. The regressors, on the other hand, are all real variables.

The coefficients need not be the same in this model, because the parameter α, governing the frequency of price adjustment, is endogenous to the rate of inflation (Ball et al. 1988, Kiley 2000). This coefficient is expected to be greater in the ruble-pricing cities, as ruble inflation has been high throughout this period. Since both coefficients in (6) are positive functions of α in absolute value, we expect them to be bigger as well in the ruble cities.

The results are reported in Table 1. These results are obtained using the seasonaly adjusted CPI and aggregate real income data from Goskomstat, the Russian federal statistical commission.

The results in Table 1 demonstrate that the rational expectations sticky price model does not describe the data well. Most importantly, the coefficient in front of income is positive, not negative, in the regressions for ruble cities. This result is commonly obtained in tests of sticky-price models: inflation is found to be rising in times of boom, contrary to the prediction of the model. At the same time, for dollar cities the coefficient has a correct negative sign.

Even more disastrous is that the relative apartment price uniformly enters negatively and in most cases significantly, while the predicted sign is positive.

Table 1: Testing the rational expectations model

Dependent variable $\Delta\pi^a_{t+1}$			
City	Constant	y_{t+1}	$p^a_t - p_t$
Panel regressions:			
All dollar cities (fixed effects)		-0.050	**-0.055**
		(0.046)	**(0.027)**
All ruble cities (fixed effects)		0.128	**-0.163**
		(0.079)	**(0.055)**
Individual dollar cities:			
Moscow	0.126	-0.017	-0.012
	(0.110)	(0.021)	(0.011)
St.Petersburg	**0.419**	**-0.064**	**-0.038**
	(0.122)	**(0.026)**	**(0.009)**
Kaliningrad	0.390	-0.035	**-0.067**
	(0.386)	(0.079)	**(0.026)**
Nizhny Novgorod	0.417	-0.033	**-0.080**
	(0.372)	(0.080)	**(0.044)**
Tver	**0.361**	-0.050	**-0.046**
	(0.160)	(0.037)	**(0.016)**
Individual ruble cities:			
Novosibirsk	0.192	0.184	**-0.306**
	(0.297)	(0.114)	**(0.147)**
Omsk	0.127	0.037	**-0.102**
	(0.468)	(0.107)	**(0.045)**
Perm	**-0.277**	0.196	**-0.182**
	(0.411)	(0.123)	**(0.080)**
Ulyanovsk	-0.097	0.092	**-0.109**
	(0.227)	(0.066)	**(0.044)**

The problem with predicted falling inflation at times of high income is normally fixed by switching to either some form of adaptive expectations (), or by switching to sticky-information models, recently proposed by Mankiw and Reis (2001a, 2001b). We now turn to adaptive expectations, and will consider sticky information in Section 4.

3.2 Adaptive expectations

The simplest method to introduce adaptive expectations is to simply assume that the sellers expect the desired price in the future to be the same as the desired price today. This assumption gives a very simple solution to the behavior of prices: reset price is simply replaced by the desired price, for which there is a clear expression. The only problem is that such behavior, unlike the rational expectations one, is difficult to reconcile with trend ruble inflation, which was present in Russia in the period under study, at least after the August 1998 crisis. A way to fix that problem is then to assume that each seller, when setting the price, adds an increment of the current inflation rate in the country to the reset price, otherwise obtained from this form of static expectations.

Thus, the expressions for the reset price, combined with (1) are

$$b_t = p_t^a + \beta q_t \tag{7}$$

in dollar cities, and

$$b_t = p_t^a + \beta q_t + \frac{1}{\alpha}\Delta p_{t+1}. \tag{8}$$

Thus, it is assumed that there is no trend inflation in dollars, while each seller in a ruble city adds the current inflation times $1/\alpha$ - the length of time during which her price is expected to be fixed.

The testable equations then become, after combining the above two equations with (2) and (3),

$$\Delta p_{t+1}^a = -\alpha\beta\gamma(p_t^a - p_t) + \alpha\beta y_{t+1} \tag{9}$$

for the dollar cities, and

$$\Delta p_{t+1}^a - \Delta p_{t+1} = -\alpha\beta\gamma(p_t^a - p_t) + \alpha\beta y_{t+1} \tag{10}$$

for the ruble cities. These equations are quite intuitive. The apartment prices grow when their relative price is low and when the demand is high. They fall when the opposite is true.

Once again, the coefficient for the ruble cities are expected to be greater, as sellers must be adjusting their prices more frequently in an inflationary environment.

The results of the estimation of (9) and (10) are shown in Table 2. These results are reported both using the aggregate Russian money income, and regional money incomes of the corresponding cities. Although the regional incomes may seem to be a better variable to use, the quality of measurement of regional income, especially at monthly frequencies, is very questionable. Hence, we report the results obtained both with the aggregate, which is supposedly easier to measure, and the regional incomes. The results do not seem to depend greatly on this choice of income measure.

It is immediately seen that the model with adaptive expectations does much better than the model with rational expectations. Indeed, for panel estimation, all of the coefficients are significant and have the correct sign. For individual cities, coefficients are not always significant, but the sign is always as predicted. As expected, the coefficients for ruble cities are all bigger in absolute value than those for dollar cities.

4 Sticky information

Mankiw and Reis (2001a, 2001b) propose an alternative explanation for the apparent slow response of the aggregate price level to changes in the economic environment. They assume that individual sellers face some costs of obtaining information necessary for price formation. The existence of such information costs implies that an individual price-setter updates her information occasionally, from time to time, rather than in a continuous manner. After buying a new portion of information, the seller resets the whole trajectory of the price for her product, which will be in force until the

Table 2: Testing the adaptive expectations model

Dependent variable Δp^a_{t+1} for dollar cities, $\Delta p^a_{t+1} - \Delta p_{t+1}$ for ruble cities						
	Using aggregate income			Using regional income		
City	Constant	y_{t+1}	$p^a_t - p_t$	Constant	y_{t+1}	$p^a_t - p_t$
Panel regressions:						
All dollar cities (fixed effects)		**0.410**	**-0.110**		**0.177**	**-0.129**
		(0.123)	**(0.058)**		**(0.066)**	**(0.059)**
All ruble cities (fixed effects)		**0.419**	**-0.209**		**0.215**	**-0.235**
		(0.088)	**(0.051)**		**(0.058)**	**(0.064)**
Individual dollar cities:						
Moscow	-1.170	0.363	-0.093	0.669	0.200	**-0.147**
	(1.540)	(0.319)	(0.081)	(0.356)	(0.155)	**(0.080)**
St.Petersburg	-1.784	0.475	-0.072	0.179	0.342	-0.049
	(1.656)	(0.352)	(0.066)	(0.293)	(0.216)	(0.080)
Kaliningrad	-0.546	0.239	**-0.139**	0.582	0.038	**-0.165**
	(1.585)	(0.342)	**(0.065)**	(0.229)	(0.134)	**(0.065)**
Nizhny Novgorod	-2.029	0.554	**-0.110**	**0.476**	0.195	**-0.128**
	(1.537)	(0.343)	**(0.059)**	**(0.206)**	(0.130)	**(0.061)**
Tver	-1.422	0.437	**-0.153**	**0.522**	0.147	**-0.164**
	(1.376)	(0.303)	**(0.056)**	**(0.165)**	(0.107)	**(0.056)**
Individual ruble cities:						
Novosibirsk	-0.858	**0.354**	**-0.206**	**0.892**	**0.255**	**-0.282**
	(0.666)	**(0.172)**	**(0.114)**	**(0.505)**	**(0.114)**	**(0.158)**
Omsk	**-1.448**	**0.443**	**-0.166**	**1.042**	**0.400**	**-0.349**
	(0.744)	**(0.190)**	**(0.067)**	**(0.405)**	**(0.154)**	**(0.136)**
Perm	-1.705	0.612	-0.298	0.588	0.197	-0.180
	(1.117)	(0.374)	(0.180)	(0.545)	(0.221)	(0.169)
Ulyanovsk	**-1.045**	**0.387**	**-0.228**	0.568	0.116	-0.192
	(0.606)	**(0.170)**	**(0.083)**	(0.364)	(0.099)	(0.122)

next resetting. The sticky information model is thus a multi-period generalization of Fischer (1977) model with predetermined prices.

To be specific, assume that every period only a fraction α of sellers updates their information about macroeconomic conditions and adjusts optimal, or "desired" price paths. At time t, the price-setter who updated her information s periods ago for the last time, sets the price

$$b^s_t = E_{t-s} p^{\#}_t \tag{11}$$

where $E_{t-s}(\cdot)$ denotes the expectation operator conditional on the information available at time $t-s$ and $p^{\#}_t$ is the "desired price" at time t. Then the aggregate price level on the market for apartments at time t is

$$p^a_t = \alpha \sum_{s=0}^{\infty} (1-\alpha)^s b^s_t. \tag{12}$$

Substituting (11) into (12) and using (1), we obtain

$$p_t^a = \alpha \sum_{s=0}^{\infty} (1-\alpha)^s E_{t-s}(p_t^a + \beta q_t), \tag{13}$$

which, in turn, can be transformed to the following equation for π_t^a:

$$\pi_t^a = \frac{\alpha\beta}{1-\alpha} q_t + \alpha \sum_{s=0}^{\infty} (1-\alpha)^s E_{t-s}(\pi_t^a + \beta \Delta q_t) \tag{14}$$

where, according to (2),

$$q_t = y_t - \gamma(p_t^a - p_t). \tag{15}$$

Taking the first difference of q_t, we get

$$\Delta q_t = \Delta y_t - \gamma(\pi_t^a - \pi_t). \tag{16}$$

Substituting (15) and (16) into (14) we obtain

$$\pi_t^a = \frac{\alpha\beta}{1-\alpha}(y_t - \gamma(p_t^a - p_t)) + \alpha \sum_{s=0}^{\infty} (1-\alpha)^s E_{t-s-1}(\pi_t^a + \beta(\Delta y_t - \gamma(\pi_t^a - \pi_t))). \tag{17}$$

We can interpret (17) as a stochastic difference equation for the determination of the relative, or real price for the apartments, $p_t^a - p_t$, where the processes for π_t and y_t are exogenously given.

Assume that π_t and y_t are stationary and follow independent AR(1) processes. Then we can solve the equation (17). The solution takes the form:

$$p_t^a - p_t = \sum_{s=0}^{\infty} (\phi_s y_{t-s} + \psi_s \pi_{t-s}) \tag{18}$$

where coefficients $\{\phi_s\}_{s=0}^{\infty}$ and $\{\psi_s\}_{s=0}^{\infty}$ are expressed in terms of structural parameters of the model and the parameters of underlying autoregression processes for y_t and π_t. The exact expressions can be found using the method of undetermined coefficients, and the parameters in front of contemporaneous income and inflation are:

$$\phi_0 = \frac{\frac{\alpha\beta}{1-\alpha}}{1 + \frac{\alpha\beta\gamma}{1-\alpha}} > 0 \tag{19}$$

and

$$\psi_0 = -\frac{1}{1 + \frac{\alpha\beta\gamma}{1-\alpha}} < 0. \tag{20}$$

The signs of these coefficients are intuitive. Increase in income stimulates those who update information today to adjust their price upward, hence the positive sign. A surprise increase in overall inflation, on the other hand, leaves the predetermined apartment prices of this period behind the overall price level.

Table 3: Testing the sticky information model: fixed-effect panel-data regressions

Dependent variable $p^a_{i,t} - p_t$				
	Using aggregate income		Using regional income	
Regressor	All dollar cities	All ruble cities	All dollar cities	All ruble cities
$p^a_{i,t-1} - p_{t-1}$	-0.450	**1.004**	**-0.730**	**1.041**
	(0.342)	**(0.077)**	**(0.398)**	**(0.074)**
$p^a_{i,t-2} - p_{t-2}$	**1.270**	-0.095	**1.337**	-0.125
	(0.324)	(0.075)	**(0.361)**	(0.082)
y_t	**1.584**	**0.593**	**0.341**	**0.236**
	(0.306)	**(0.144)**	**(0.086)**	**(0.074)**
y_{t-1}	**-0.374**	-0.210	**-0.108**	-0.103
	(0.165)	(0.160)	**(0.062)**	(0.073)
y_{t-2}	**-0.688**	-0.064	-0.049	0.004
	(0.240)	(0.131)	(0.065)	(0.068)
π_t or $\pi_t - \varepsilon_t$	**-3.331**	**-0.681**	**-3.312**	**-1.009**
	(0.828)	**(0.116)**	**(0.922)**	**(0.080)**
π_{t-1} or $\pi_{t-1} - \varepsilon_{t-1}$	**0.587**	0.315	**0.500**	**0.378**
	(0.209)	(0.191)	**(0.215)**	**(0.155)**
π_{t-2} or $\pi_{t-2} - \varepsilon_{t-2}$	0.038	0.336	**-0.278**	0.160
	(0.153)	(0.217)	**(0.116)**	(0.164)

In the case of dollar pricing, the analogue of (18) is

$$p^a_t - p_t = \sum_{s=0}^{\infty} (\phi_s y_{t-s} + \psi_s(\pi_{t-s} - \varepsilon_{t-s})) \tag{21}$$

where the lags of the overall inflation in ruble terms in the second sum are replaced with the corresponding lags of the overall inflation in dollar terms, which equals to the former minus the rate of ruble depreciation, ε_t.

We can test equations (18) and (21) by estimating the following panel-data regressions:

$$p^a_{i,t} - p_t = \sum_{l=1}^{2} a_l(p^a_{i,t-l} - p_{t-l}) + \sum_{l=0}^{2} (b_l y_{i,t-l} + c_l \pi_{t-l}) + \eta_t \tag{22}$$

for ruble cities and

$$p^a_{i,t} - p_t = \sum_{l=1}^{2} a_l(p^a_{i,t-l} - p_{t-l}) + \sum_{l=0}^{2} (b_l y_{i,t-l} + c_l(\pi_{t-l} - \varepsilon_{t-l})) + \eta_t \tag{23}$$

for dollar cities separately and estimating $\hat{\phi}_0 = \hat{b}_0$ and $\hat{\psi}_0 = \hat{c}_0$. The estimated regressions are shown in Table 3.

The table shows that the sticky information model enjoys only weak support of econometric tests. The most important problem is that the coefficients differ markedly between dollar and ruble cities. The coefficients in front of lagged relative price are of opposite sign, in one case both being

Table 4: Testing the flexible price model: fixed-effect panel-data regressions

Dependent variable $p^a_{i,t} - p_t$	
Cities	y_t
All dollar cities (aggregate income)	**-0.453**
	(0.134)
All ruble cities (aggregate income)	**1.089**
	(0.078)
All dollar cities (regional income)	**-0.199**
	(0.082)
All ruble cities (regional income)	**0.803**
	(0.049)

significantly different from zero. The coefficients in front of current inflation are of the same sign but very different between dollar and ruble cities, which suggests that the sticky information model can't be the unified model that explains differences between the two cities. At the same time, most of the coefficients are of the expected sign, and hence the model cannot be rejected outright.

Intuition also suggests that sticky information is unlikely to account for the differences observed between the two groups of cities. The prices in this model are completely flexible, and information was likely to be the same in all cities. Hence, we would expect that prices to behave identically as well. After all, it is hard to believe that is cities where apartments are priced in dollars people noticed the financial crisis differently than in the other cities.

5 Flexible prices

If the prices were flexible then we would expect the price level to be equal to the desired price at all times, and hence demand for the apartments to remain at a constant level, $\overline{q}$. This level is equal to the demand at the natural level of total income. Thus, under flexible prices, equation (2) takes the form:

$$q_t = y_t - \gamma(p^a_t - p_t) = \overline{q} \tag{24}$$

Equation (24) can be tested by regressing the relative, or real price for apartments on the real income:

$$p^a_t - p_t = a + by_t + \eta_t. \tag{25}$$

The estimated fixed-effect panel-data regressions are reported in Table 4. We see that the coefficient of real income is positive and significant for ruble cities while negative and significant for dollar cities. Obviously, this finding is not compatible with equation (24), which implies that both the sign and the value of the real income coefficients must be the same in both cases. Hence, the flexible price assumption has to be dismissed outright, as seems intuitive from Figure 2.

6 Conclusions

Behavior of apartment prices in different Russian cities following the devaluation in August 1998 clearly lends support to the hypothesis that prices on this market are sticky, and price formation is backward-looking rather than forward looking. In the cities, where the apartments are commonly priced in dollars, apartment prices responded slowly to the falling income, so they turned out to be relatively high comparing to the overall price level. In the cities, where apartments are priced in rubles, dollar equivalents of these prices fell dramatically on impact in September 1998, and remained low through the next three years. They then recovered faster when income picked up. Both common sense and formal testing performed in this paper show that such behavior is not consistent with flexible prices, nor it is consistent with sticky information models: clearly, people in all cities had the same information about what was happening. What was going on is that every apartment offered on the market was priced according to the average price on the market at the time and the price remained fixed for a certain time period. Hence, the prices changed slowly in the currency, in which they were denominated. The rapid devaluation of the ruble, on the other hand, forced a dramatic fall in the dollar-equivalent of the ruble-denominated apartment prices.

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