Price Dynamics in Repressive Economies: Evidence from the Belarusian Black Market for Foreign Exchange

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Summary

Using data on the black market for currencies in Belarus, we provide evidence on how access to advanced information technologies undermines centralized price-setting. `www.prokopovi.ch`, a website launched in April 2011, allowed Belarusian citizens to circumvent fixed exchange rates. The government repeatedly devalued the Belarusian ruble and eventually abandoned its fixed exchange rate regime. We show that trading activity via `www.prokopovi.ch` is highly correlated with government action. Trading volume and black market spreads have strong predictive power for the devaluations. In line with standard economic theory, activity in the black market has dried up after exchange rates were allowed to freely float. Our paper therefore points at the technology-driven nature of increased economic freedom.

Keywords: Black market, FX market, Technological progress, Price setting.

JEL Classification Numbers: O17, O33, P22, F31.

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1 Introduction

We empirically investigate the interplay between black market and official exchange rates in Belarus. We use information from `www.prokopovi.ch`, an internet platform that was launched in April 2011. `www.prokopovi.ch` allowed Belarusian citizens to trade in a functioning two-way market which, as we show, incorporated publicly available information in an efficient manner due to the absence of government intervention.[1] We were able to create a daily-level data set that spans a period of time which coincides with a currency crisis. A continued deterioration of the current account and diminishing official reserve assets in early 2011 led to increased dysfunction of the official foreign exchange market within Belarus as banks increasingly refused to sell foreign currency at the official rates. Starting in May 2011, the Lukashenko regime has repeatedly devalued the Belarusian ruble and finally abandoned fixed exchange rates which had significantly overvalued the Belarusian ruble. We use different statistical techniques to investigate how the official and black market exchanges rates have interacted during this period. Our data suggest that the devaluations and the transition towards a free floating regime were anticipated by the black market.

The course of events may have been affected by the very source of our data. Part of the existing literature on black markets for foreign exchange (e.g. Dornbusch, Dantas, Pechman, de Rezende Rocha, and Simões, 1983) treats official exchange rates and interest rates as exogenous to black market activity. In some settings, black markets are small enough to assume that their economic impact is negligible. But their role may have changed. There are two reasons why the decisions of policy makers in repressive economies have become more likely to be affected by activity in black markets since the emergence of the internet. First, the internet has reduced the costs of transactions in black markets, leading to an increase in activity. *Facebook* may have had a similar effect in Cairo in 2011: Tufekci and Wilson (2012) surveyed protestors on Tahrir Square. They find that social networks help people overcome coordination problems. Second, the internet has made black market exchange rates observable to a broader public. Shortages of foreign currency already indicated an overvaluation of the Belarusian ruble, but the website made market-clearing values publicly available information. This increased transparency may have reinforced people's doubts regarding the sustainability of the fixed exchange rate regime. Callen and Long (2011) provide field-experimental evidence that the availability of mobile phones with photo

[1] Black markets for foreign exchange are illegal but usually tolerated by governments, which is why they are often referred to as parallel markets.

cameras reduced election fraud in Afghanistan. Unlike Callen and Long (2011), we do unfortunately not have a counterfactual event without the website that we could use to measure the impact that this technology had on government action.

The Lukashenko regime has remained in power since 1994 on its mostly delivered promise of social stability and fast economic growth achieved in part through the aggressive use of easy monetary policy. Central banks in industrialized countries have long used their control over short-term interest rates to stabilize the business cycle. However, such policies create economic distortions: not only do artificially low interest rates increase the medium-term risks of inflation, they also represent a tax on savings and a subsidy on spending which may lead to misallocations of capital to potentially unproductive means. In repressive economies like Belarus, expansionary policies are typically used more excessively and, given the rigidities related to central planning, less effectively (Ding and Kovtun, 2010). Korosteleva (2007) describes the aim of Belarus's central bank as "maximizing seigniorage and inflation tax." While the Belarusian central bank has pursued an aggressive inflationary policy, it has, at the same time, tried to keep the country's currency stable on the foreign exchange market over an extended period. The fixed exchange rate significantly overvalued the ruble and distorted Belarus's trade balance, inducing a persistent current account deficit.

Growing activity in the shadow sector is often related to people feeling overburdened by restrictions imposed upon them by the state (Schneider, 2005). The emergence of a black market for foreign exchange is, therefore, only a logical consequence of Belarus' exchange rate policy and the resulting shortage of foreign exchange in the official market. The launch of `www.prokopovi.ch` was likely beneficial for Belarusians: Rogoff (1998) mentions the possibility that the use of foreign currencies like the dollar or the euro may be efficiency enhancing because it offers a higher degree of price stability. However, he also mentions a potentially harmful effect - the possibility that if governments cannot use seignorage anymore, they may resort to other, potentially even more distortive forms of taxation.

The paper is organized as follows. Section 2 provides a brief information on the economic conditions in Belarus and on the Belarusian foreign exchange policies during the investigated time period. Section 3 describes the data sets used and summarizes the main features of the data. Section 4 investigates the time series properties of the underlying data and analysis possible causal relations between the time series.

Section 5 discusses the results and concludes the paper.

2 Background

Along with fellow non-reformer Uzbekistan, Belarus was the only former Soviet state that did not experience a contraction in the 1990s due to the removal of misallocations of economic activity (Shleifer and Treisman, 2005). The other transition economies of the former Soviet Union grew moderately in the 1980s, declined sharply after the collapse of the Soviet Union, but have been expanding rapidly since around the year 2000. Belarus' centrally planned economy is still characterized by an emphasis on heavy industry over light industry and on industry over services (Ickes and Ofer, 2006).

The financial crisis has had a profound impact on Belarus' economy (Ding and Kovtun, 2010; Korosteleva, 2011; Ioffe and Yarashevich, 2011). After several years of rapid economic growth fueled by cheap, subsidized, Russian energy imports the country ran into severe troubles in late 2010, early 2011. Several shocks that occurred in short order led to a currency crisis in the first half of 2011. Following a year-long dispute with Moscow over the price charged for its oil exports, Russia temporarily suspended oil shipments on Jan 1, 2011. Energy imports to Belarus totalled around 20 million tons in 2010, only 7 of which were consumed domestically, while roughly two thirds were refined and sold at market prices to Western europe, in particular Poland and Germany at an enormous profit and providing much needed hard currency inflows. Second, as a consequence of the world-wide economic slowdown international demand for the heavy machinery that makes up a significant share of Belarus' exports collapsed. These economic problems were complemented by a spending frenzy of President Alexander Lukashenko prior to the presidential election of 2010 in an effort to gain popular support.

As a result foreign currency reserves fell to around \$3.8bn and the current account deficit widened to 16% of GDP. Following this substantial loss of reserves in the beginning of 2011 a heavily depreciated black market exchange rate emerged (Husain and Arora, 2012). In May 2011, Russia decided to keep Belarus afloat with a \$3bn loan from the Eurasian Economic community (Korosteleva, 2011), but at the cost of transferring ownership rights in the all-important pipeline used to transport Russian gas to Western europe, by some accounts the only strategic asset of the country. Following the disputed election of December 2010, Lukashenko's violent crack-down on protestors spoiled relationships with the U.S. and E.U. therefore making it difficult to turn to them for help.

As noted by Zlotnikov (2011), in the beginning of 2011, the Belarusian Central Bank tried to lessen public demand for foreign currency by limiting the access of private agents, and especially small- and medium-sized enterprises (SMEs), to available cash. Although, President Lukashenko insisted that foreign currency reserves would be sufficient to meet household demand, devaluation expectations had become stronger. The Belarusian ruble exchange rate was maintained within two percent of its fixed value. Despite increasing devaluation expectations, the regime announced that previous restrictions on foreign exchange trading would be lifted as of April 1, 2011. Ultimately, however, this proved infeasible. Due to the inevitable depletion of foreign exchange and gold reserves, the Central Bank froze the sales of foreign currency to private actors and stopped selling foreign currency to commercial banks on March 22, 2011. Despite the obvious shortage of foreign currency the devaluation could be avoided until May 24. On May 25 Belarus devalued the ruble by 56% from 3156 to 4931 ruble per US dollar. The central bank had refused a devaluation until it became inevitable. (Husain and Arora, 2012) notes that even after first devaluation the parallel exchange market persisted, giving rise to a multiple exchange rate system. The first devaluation followed by several adjustment for foreign exchange rates. The second leg of the devaluation occurred on September 21, 2011 when the ruble was devalued from 5413 to 7975. In the preceding two weeks, however the ruble already fell from 5220 to 5413. This second devaluation was announced two weeks in advance: on August 30, 2011, President Alexander Lukashenko said that the change would be implemented via a special trading session at the currency exchange, which would kick off on September 12. The exchange rate would henceforth be "determined by supply and demand, like any other product."[2]

During the special trading sessions, banks and companies were able to buy and sell foreign currency without limitation and banks were obliged to sell foreign exchange to the population at the same rate. In addition, a separate preferential rate was applied to energy payments in ordinary trading sessions. The central bank used this foreign exchange session to test demand for the ruble to find the appropriate exchange rate level, meaning this was not a de facto free float but an attempt to legalize the quasi-legal exchange that had flourished in the weeks before. The official

[2]See `http://telegraf.by/en/2012/02/lukashenko-500-dollarov-eto-sovsem-nizkii-uroven-zarplat` and `http://www.belta.by/ru/all_news/president/Kurs-belorusskogo-rublja-budet-opredeljatsja-sprosom-i-predlozheniem--Lukashenko_i_569998.html`.

exchange rate was not entirely flexible until a minor third devaluation. This final leg occurred on October 12, when it was adjusted again from 7720 to 8750. On October 20, 2011 Belarus finally officially integrated the foreign exchange market segments and moved the exchange rate to a "full market free float." The market rate on this day was 8680, 52% weaker then previous day's official rate. In April 2012, the ruble traded at 8070 and thus has stabilized in the floating exchange regime. It has actually gained around 11% since the all-time low of 9010 rubles on the dollar in mid October 2011.

3 Data

For the empirical analysis we use data on exchange rates of the Belarusian ruble (BYR) versus three foreign currencies, namely the US dollar (USD), the euro (EUR) and the Russian ruble (RUB), from three different sources. The first source is the National Bank of Belarus (NBB).[3] The official website of the NBB provides official exchange rate data of the BYR versus foreign currencies set by the NBB on a daily basis. The second source of exchange rate data is Bloomberg. Finally, the source of our black market data is the website `www.prokopovi.ch`. The website `www.prokopovi.ch`, named after the by now sacked chairman of Belarus' central bank, Petr Prokopovich, was set up in April 2011. People willing to buy or sell foreign currency have the possibility to publish their offers on `www.prokopovi.ch`. In these bids and offers, they specify the currency, the amount, the rate at which they want to trade, and the city. Potential trading partners can see these offers and, after typing in a CAPTCHA code,[4] contact the person who made the offer to arrange a meeting. Trade can, of course, take place anywhere. It should, however, be mentioned that very often it takes place in official currency-trading booths - nominally at the official rate but including side payments. Unfortunately, we have no information about what happened after the offers were posted, i.e. we do not know whether offers led to transactions. As mentioned in the introduction, black market exchange rates should be mirror the free market value of the currency. That a "heavily depreciated black market exchange rate" that emerged after arising shortages of foreign exchange was an important indicator of the true economic situation in Belarus was also noted by the IMF (Husain and Arora, 2012).

[3] `http://www.nbrb.by/engl/statistics/rates/ratesDaily.asp`.

[4] CAPTCHA is an acronym that stands for "Completely Automated Public Turing test to tell Computers and Humans Apart." A CAPTCHA code is meant to make sure that a response is generated by a person.

We have information on all offers that were made between the launch of the website and January 21, 2012. This includes 145'246 entries in total. After dropping all those advertisements, which do not involve Belarusian rubles on the one hand, and either US dollars, euros or Russian rubles on the other hand, we are left with 139'579 entries. 89.7% of these advertisements indicated that the transactions were supposed to take place in Minsk. Activity is much lower in the remaining parts of the country. Table 3.1 shows the numbers for the six biggest cities in Belarus including the capital Minsk. Out of the 139'579 offers, 102'659 (73.55%) involved exchanges between Belarusian rubles and US dollars, 18'933 (13.56%) involved exchanges between Belarusian rubles and euros and 17'987 (12.89%) involved exchanges between Belarusian rubles and Russian rubles.

Table 3.1: Distribution of Offers Across Cities.

ID	city	pop (2010)	offers	percent	offers/pop
1	Minsk	1'834'200	124'805	89.42	0.0680
2	Gomel	484'300	2'800	2.01	0.0058
3	Brest	310'800	3'040	2.18	0.0098
4	Grodno	328'000	2'189	1.57	0.0067
5	Vitebsk	348'800	2'087	1.50	0.0060
6	Mogilev	354'000	1'536	1.10	0.0043
	...				
	Belarus	9'503'807	139'579	100.00	0.0147

Note: Entire period until January 25, 2012.

Table 3.2: Volume of dollar Offers Across Cities.

ID	city	pop (2010)	vol.(mio $US)	percent	vol. ($US)/pop
1	Minsk	1'834'200	109'475.08	99.8850	59'685.46
2	Gomel	484'300	30.15	0.0003	62.26
3	Brest	310'800	38.91	0.0004	125.21
4	Grodno	328'000	16.60	0.0002	50.62
5	Vitebsk	348'800	20.07	0.0002	57.55
6	Mogilev	354'000	12.18	0.0001	34.41
	...				
	Belarus	9'503'807	109'601.51	100.00	11'532.379

Note: Entire period until January 25, 2012.

Table 3.3: Volume of euro Offers Across Cities.

ID	city	pop (2010)	vol.(mio EUR)	percent	vol. (EUR)/pop
1	Minsk	1'834'200	1'463.58	99.5237	797.94
2	Gomel	484'300	0.98	0.0006	2.03
3	Brest	310'800	2.06	0.0014	6.62
4	Grodno	328'000	0.82	0.0006	2.51
5	Vitebsk	348'800	1.11	0.0008	3.19
6	Mogilev	354'000	0.29	0.0002	0.81
	...				
	Belarus	9'503'807	1'470.59	100.00	154.74

Note: Entire period until January 25, 2012.

Table 3.4: Volume of Russian ruble Offers Across Cities.

ID	city	pop (2010)	vol.(mio RUR)	percent	vol. (RUR)/pop
1	Minsk	1'834'200	53'191.40	0.9906	28'999.78
2	Gomel	484'300	159.06	0.0030	328.44
3	Brest	310'800	29.84	0.0006	96.00
4	Grodno	328'000	21.24	0.0004	64.76
5	Vitebsk	348'800	172.91	0.0032	495.72
6	Mogilev	354'000	34.61	0.0006	97.76
	...				
	Belarus	9'503'807	53'698.14	100.00	5'650.17

Note: Entire period until January 25, 2012.

For our analysis, we aggregated the black market exchange rates at the daily level. More precisely, we computed volume-weighted average exchange rates for all three currencies c

$$XR_{itc} = \frac{\sum_j XR_{jitc} q_{jitc}}{\sum_j q_{jitc}},$$

where XR_{jtci} are the rates stated and q_{jtci} are the quantities stated in all offers j made through the website for trades in city i for all days t between April 22, 2011 and January 21, 2012. All subsequent analyses in this paper use this volume-weighted average exchange rates.

In Figure 1, the time series of the official exchange rate, the black market exchange rate and trade volumes in the black market are shown for the time period from

April 22, 2011 to January, 21 2012 three currencies: USD, EUR and RUB. The Bloomberg data and official exchange rates are almost identical until September 21, 2011. With the implementation of two segments as explained in previous section, they deviate from each other. One segment was allowed to operate under managed float exchange rate regime to test supply and demand. This segment is clearly captured by Bloomberg data which can be seen by the convergence of black market rates and Bloomberg data during this one month long period during which two segments existed. After the introduction of a free-floating exchange rate all three series start to move together.

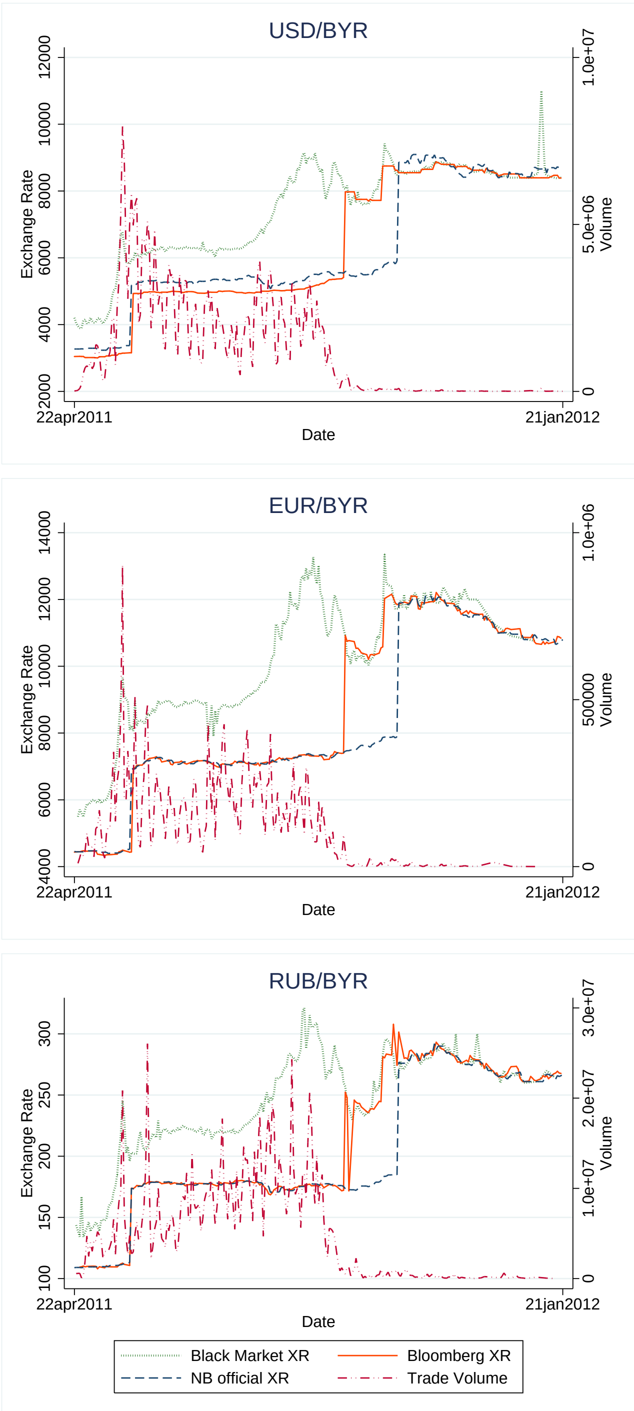

Figure 3.1: Exchange rates and Volumes

At the beginning of our sample period on April 22, 2011, there is an obvious difference between the black market rates and official rates for all three currencies. Just before the first devaluation on May 25, 2011, both the transaction volume in the black market and black market exchange rates experience a peak. Transaction volume decreases after the devaluation and remains at around the same level, although with fluctuations, until shortly before the second leg of devaluations. Close to the introduction of the two segments in the foreign exchange market the transaction volume decreases gradually and, as expected, falls almost to zero with the introduction of free floating exchange rate regime. The black market exchange rates, however, stayed higher than official rates even after first devaluations indicating that the devaluation was not sufficient to reach the market value of the BYR. Another jump in the black market exchange rates occurred before the introduction of two segments. The jumps in black market exchange rates before these two events suggest that the devaluations were anticipated by the market participants.

4 Black Market versus Official Exchange Rates

4.1 Why Does the Black Market Matter?

Price controls are not binding when a parallel market emerges, in which people are able to trade at market rates. Reinhart and Rogoff (2004) observe that in most countries that enacted price controls in the foreign exchanges market, i.e. "pegs," since WWII, black markets emerged that were better indicators of monetary policy and economic conditions than official foreign exchange markets. First, the classify black markets into three different categories according to the sizes of the black market premia: they classify under 10% as low, between 10% and 50% as moderate and 50% and above as high. Figure 2 plots the three black market premia in Belarus over the period that we have data for. The upper panel uses Bloomberg's official exchange rate data, the lower panel uses the National Bank's official exchange rate data, which reflect the preferential rate until October 20, 2011. The graphs show that, according to this classification, black market premia in Belarus were most of the time in the moderate range, rose beyond the 50% threshold in anticipation of devaluations and vanished with the implementation of the free floating system.

Reinhart and Rogoff (2004) provide evidence that proxies for the size of the black markets relative to the official markets are positively correlated with the size of the black market premia. We observe a similar pattern for the volumes of offers posted on `www.prokopovi.ch` (compare Figure 1). The period before the second devaluation in September 2011 is an exception: black market premia went up, but activity did not. Since it had been announced two weeks before that a free floating system would be installed, people seem to have postponed their activity to trade later on in the official market.

But black markets do not only crowd out activity in the official markets. Reinhart and Rogoff (2004) document that they also serve as much better indicators for economic conditions and monetary policy than official exchange rates. This makes black markets an important factor for exchange rate-setting behavior. Following Reinhart and Rogoff (2004), we have performed probit regressions, in which we have regressed dummies that indicate periods around devaluations and exchange rate regime changes on black market premia and trading volume on preceding days. Unreported results show that black market premia have significant explanatory power in most of these regressions, whereas the coefficient on volume sometimes even is negative. The negative sign on the effect of volume of offers is probably due to the decrease in black market activity after the announcement of the freely floating regime on August 30, which happened before the start of the special trading sessions with two segments in the official exchange rate market on September 12. This finding does not necessarily mean that policy makers base their decisions on black market activity. The coefficients would be significant even if the black market were small and exogenous (Dornbusch, Dantas, Pechman, de Rezende Rocha, and Simões, 1983). But it implies that the black market efficiently anticipates the devaluations and regime changes that we observe in our data. (Husain and Arora, 2012) indicate that one reason for the the regime change may have been to 'legalize' activity that had taken place in the black market.

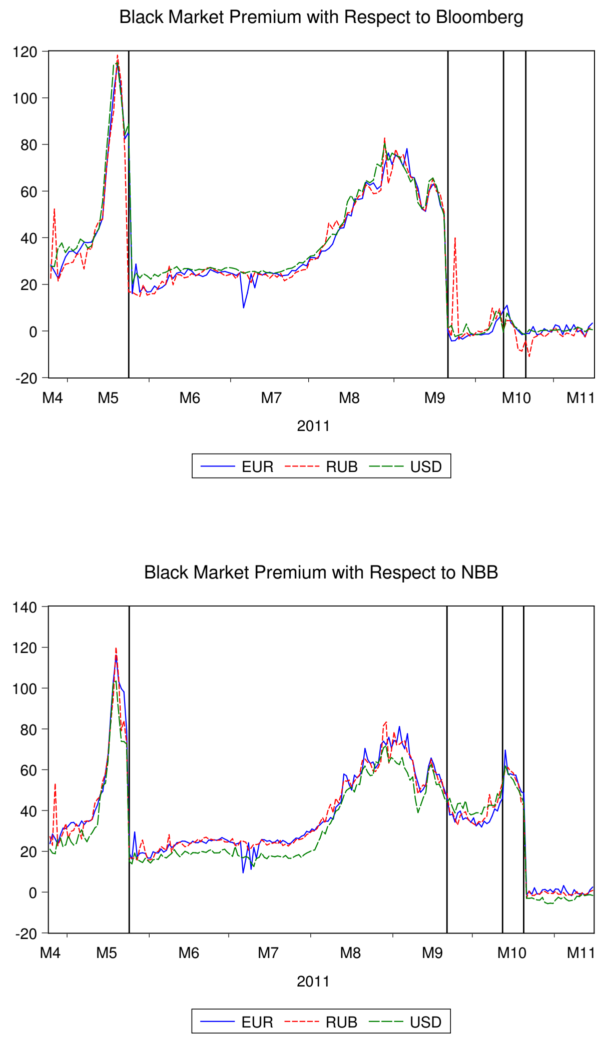

Figure 4.2: Exchange rates and Volumes

The foreign currency crisis outlined in Section 2 and increased black market activity fostered by technological change create a unique environment, in which three parallel markets coexisted and were observable for a specific period of time. Ioffe and Yarashevich (2011) note that demand for foreign currencies exceeded supply at the official rates right before the website was launched: "Belarusian banks [...] reported a shortage of hard currency. In late March 2011, hard currency altogether disappeared from the country's exchange outlets whereupon the end of unobstructed access to hard currency provoked a consumer panic with Belarusians promptly stocking up on such necessities as sugar, salt, and vinegar." Confidence in their own currency was not very high among Belarusians, anyway. The easily accessible black market and the publicly available information on the black market exchange rate might have lead Belarusians to further evoke their already low confidence.

4.2 Unit Root Tests

In this part of the study we conduct several statistical analyses to establish the time series properties and causal relations between the different exchange rate markets for the different currencies. Similar investigations were conducted by Akgiray, Aydogan, Booth, and Hatem (1989), Booth and Mustafa (1991), Moore and Phylaktis (2000), Dawson, Millsaps, and Strazicich (2007) and Caporale and Cerrato (2008). The time series from NBB are daily and available for every day. However, the black market exchange rates are only observable if there is a market transaction. Especially after the introduction of the free floating exchange rate regime, black market transactions are more rare. Therefore, we restrict our sample to the time interval from April 25, 2011 to November 15, 2011. Since this time interval includes all dates that are of interest (devaluations and regime change) and also continues almost one month after the regime change, we believe that we can capture the properties of the data using this restricted sample. Please note that for the same interval the Bloomberg exchange rates are only available for work days. This leaves us with 206 observations for black market and national bank exchange rates and 147 observations for Bloomberg exchange rates.

The first analysis we carry out is augmented DF unit-root test. The results are summarized in Table 4.5.

Table 4.5: Testing for Stationarity/Unit Root

	Level	
	statistics	p-value
BM BYR USD	-1.89	0.34
BM BYR EUR	-1.87	0.35
BM BYR RUB	-2.04	0.27
NB BYR USD	-0.52	0.88
NB BYR EUR	-0.52	0.88
NB BYR RUB	-0.55	0.88
Bloom BYR USD	-0.63	0.86
Bloom BYR EUR	-0.77	0.83
Bloom BYR RUB	-0.45	0.89

Note: Augmented D-F test.

The results of the augmented DF tests clearly indicate that all the series are $I(1)$. However, the validity of this test is questionable due to possible structural breaks in levels and trends. It has been shown that if the data generating process is trend stationary around a permanent break in the intercept and/or slope of the trend function then unit-root tests fail to reject the null hypothesis too often. Due to the devaluations and the regime change, we expect to find structural breaks. Figure 1 already gives supporting evidence on the existence of structural breaks.

Since Perron (1989) there has been an increasing literature pointing out the importance of structural breaks on unit root tests. Several alternative testing procedures have been proposed in the literature (see for example Glynn, Perera, and Verma, 2007, for a review). Most of the existing tests, however, either only deal with one structural break or multiple structural breaks with known dates. However these tests are not suitable for our study due to the following reasons. First, given two major devaluations in the time interval, considering only one structural break is not appropriate in our case. Second, while we could consider the unit root test with known multiple structural breaks for the official exchange rates, this is not the case for the black market exchange rates. There are several possibilities on how black market series are affected by structural breaks in the official exchange rates. The black market series could anticipate the structural breaks in the official rate or just follow them. To investigate these possibilities we need a procedure which allows for the endogenous determination of break dates. The test proposed by Lee and Strazicich (2003) fits to our problem very well. They propose a Lagrange multiplier unit root test with two structural breaks where the break dates are endogenously determined. Their test allows for changes in the level and/or the trend under both the null and alternative hypotheses. We consider the version with changes in both, level and trend. Under the null hypothesis the series has a unit root and under alternative the series is trend stationary. In both cases, there are two changes in the levels and trends. Formally, the null and alternative hypotheses can be written as follows:

$$H_0: \quad y_t = \mu_0 + d_1 B_{1t} + d_2 B_{2t} + d_3 D_{1t} + d_4 D_{2t} + y_{t-1} + \nu_{1t} \tag{4.1}$$

$$H_1: \quad y_t = \mu_1 + \gamma t + d_1 D_{1t} + d_2 D_{2t} + d_3 DT_{1t} + d_4 DT_{2t} + \nu_{2t}. \tag{4.2}$$

where ν_{1t} and ν_{2t} are stationary errors. Let T_{B_j} for $j = 1, 2$ denote the time period when a break occurs; $B_{jt} = 1$ for $t = T_{B_j} + 1$, $j = 1, 2$, and 0 otherwise. $D_{jt} = 1$ for $t \geq T_{B_j} + 1$, $j = 1, 2$, and 0 otherwise. $DT_{jt} = t - T_{B_j}$ for $t \geq T_{B_j} + 1$, $j = 1, 2$, and

0 otherwise.[5]

Table 4.6: Two-break minimum LM unit root tests

Series	k	T_{B1}, T_{B2}	Test-statistics	$\lambda = (T_{B1}/T, T_{B2}/T)$
BM BYR USD	3	17.05, 17.08	-3.7767	(0.12,0.56)
BM BYR EUR	3	25.05, 12.08	-3.7790	(0.16,0.54)
BM BYR RUB	0	14.05, 20.09	-3.7877	(0.10,0.73)
NB BYR USD	8	23.05, 19.10	-7.4559***	(0.15,0.87)
NB BYR EUR	8	23.05, 19.10	-7.1510***	(0.15,0.87)
NB BYR RUB	8	23.05, 19.10	-7.0139***	(0.15,0.87)
Bloom BYR USD	0	24.05, 20.09	-9.6185***	(0.15,0.73)
Bloom BYR EUR	0	19.09, 25.10	-8.0091***	(0.72,0.90)
Bloom BYR RUB	0	07.10, 21.10	-12.6405***	(0.82,0.88)

Note: k is the optimal number of lagged first-difference terms included in the unit root test to correct for serial correlation. T_{B1} and T_{B2} are the estimated break dates. λ is the location of the breaks within the sample for which critical values are determined. Critical values are reported in Table 1 of Strazicich, Lee, and Day (2004). ***, ** and * indicate significance at the 1, 5 and 10% levels, respectively.

The results of our two-break LM unit root tests are given in Table 4.6. For six out of the nine series, the unit root null hypothesis is rejected at a 1% significance level. For none of the black market exchange rates, we reject the unit root hypothesis.

In Figure 3, we plot the time series along with the estimated break dates and with the dates on which devaluations and the regime change occur. The three graphs in the first row are black market exchange rates for USD, EUR and RUB, respectively. We observe that the first break date is estimated very close to the first devaluation. For USD and RUB, the first break occurs slightly before the devaluation date. The second break occurs for USD and EUR approximately one month before the second leg of the devaluation. However, the series RUB experiences the break just before the second leg. The plot sin the second row are the exchange rates from the national bank for the same currencies. Here, we clearly see that the two endogenously estimated structural breaks coincide with the first devaluation and exchange regime change, respectively. The last row, the exchange rates from Bloomberg, show that the estimated breaks are on the dates of the first devaluation and the second leg of the devaluation. In general, we see that the test delivers quite meaningful break

[5]For the technical details please refer to Lee and Strazicich (2003).

dates for all series. The break dates for the black market time series indicate that there is an anticipation of the devaluation and the regime change.

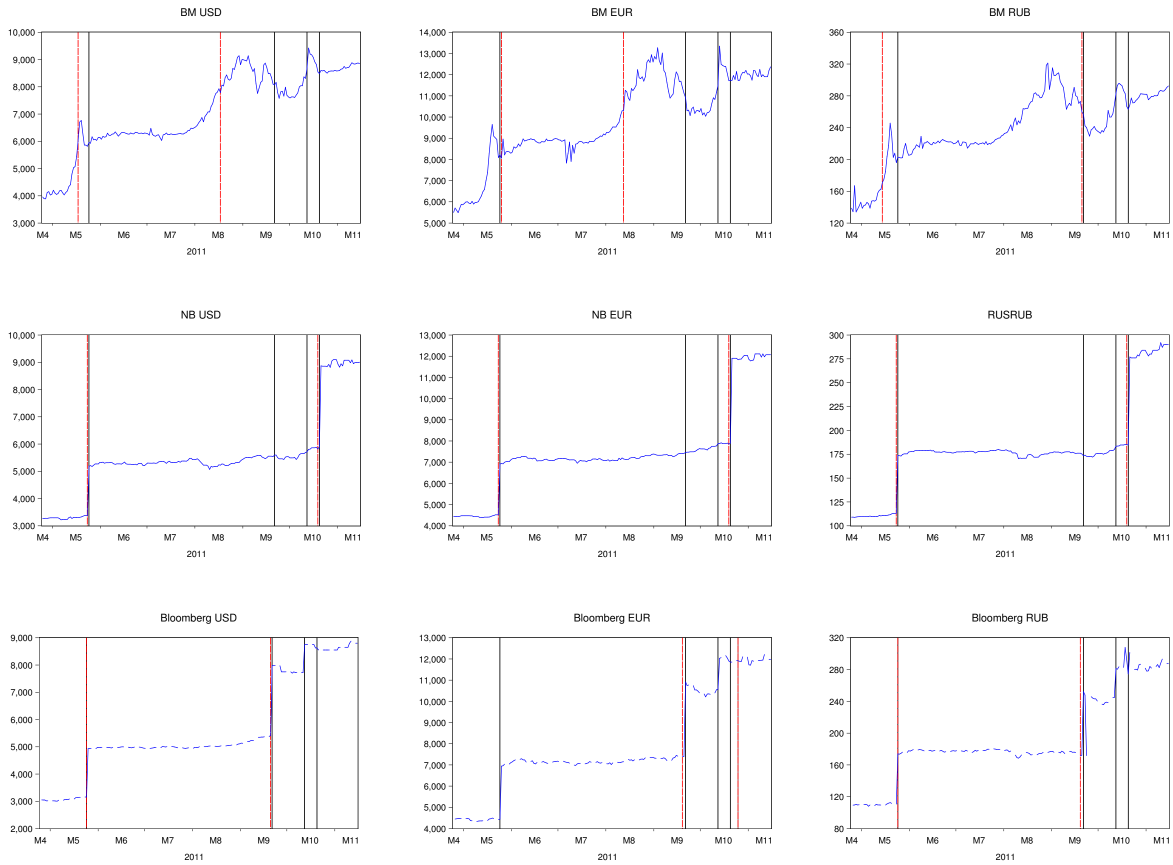

Figure 4.3: Exchange rates and Estimated Break Points: Vertical (red) dashed lines are estimated break points. Vertical (black) solid lines are the important dates, i.e. 24.05: first devaluation, 21.09: second leg of devaluation, 12.10: Final leg of devaluation, 20.10: beginning of the free floating regime

In order to apply the Granger causality test among exchange rate series we need to detrend the series. We use the results of the LM-Unit root test to detrend the series. The series, for which we rejected the unit root hypothesis, i.e. NBUSD, NBEUR, NBRUB, BUSD, BEUR, BRUB, we run the following regression:

$$Y_t = m_0 + m_1 D_{1t} + m_2 D_{2t} + m_3 t + m_4 DT_{1t} + m_5 DT_{2t} + \epsilon_t \tag{4.3}$$

The residuals from this regression, $\hat{\varepsilon}_t$, are detrended series of these series denoted by NBUSD*, NBEUR*, NBRUB*, BUSD*, BEUR*, BRUB*. The black market exchange rates, BMUSD, BMEUR, BMRUB, are detrended differently since they are non-stationary. For these series we run the following regression:

$$\Delta Y_t = m_0 + m_1 B_{1t} + m_2 B_{2t} + m_3 t + m_4 D_{1t} + m_5 D_{2t} + \epsilon_t \tag{4.4}$$

By taking first differences, we deal with the unit roots and by regressing on the structural break dummies we detrend the stationary first difference series. Again, the residuals are the detrended stationary series denoted by BMUSD*, BMEUR*, BMRUB*. In Figure 4, we plot the detrended series. For all graphs the red lines (short-dashed) lines are dependent variables from equation 4.3 or 4.4. Hence, for black market exchange rates the red lines are first differences of the exchange rates, whereas for the other two market the red lines are the actual series. The green lines (long-dashed) are the fitted series and the blue lines (solid) are the residuals which we use for the following causality analysis.

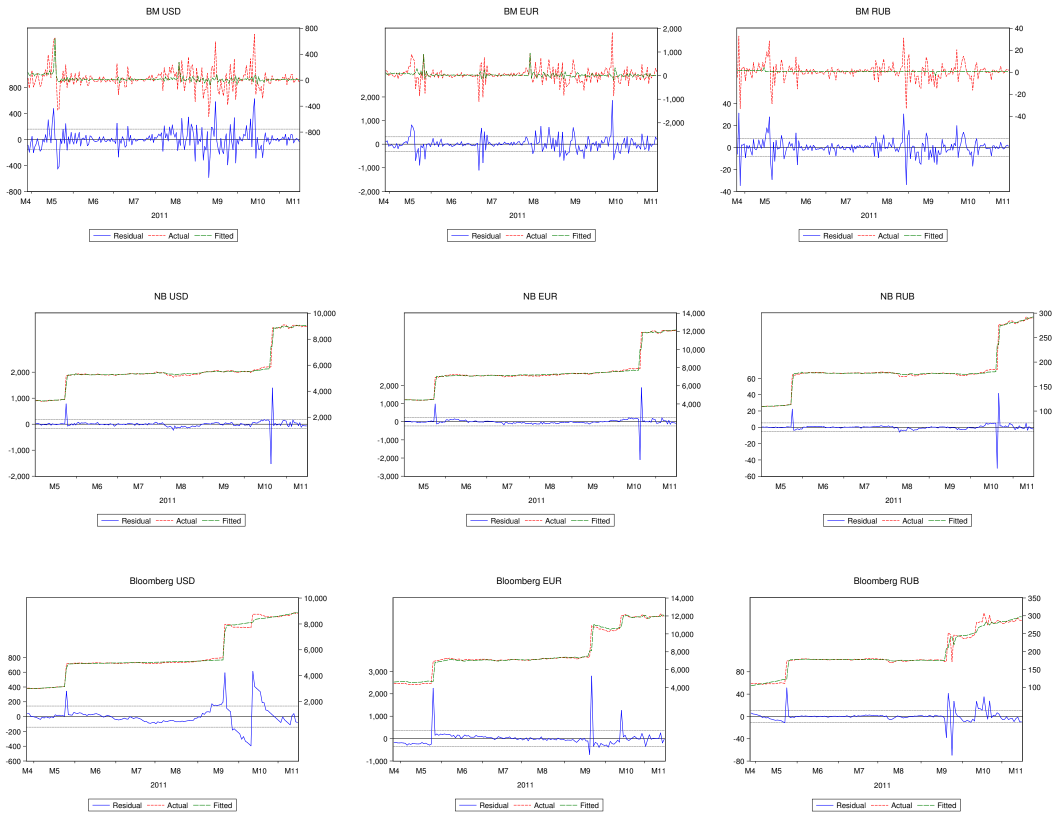

Figure 4.4: Detrended Series: The Regression equations are given in equations 4.3 and 4.4. The decision on which of these two models is used is made based on the results in Table 4.6. For stationary series equations 4.3 is used and for non-stationary series equations 4.4 is used.

4.3 Granger Causality

In the following we apply tests for Granger Causality tests to the detrended series. We investigate two important questions. The first one is the direction of causality among the different currency exchange rates in the same market, for example causality between euro and dollar exchange rates in black market. The second one is the causality between two markets, for example causality between the black market exchange rate for euro and the national bank exchange rate for euros.

Table 4.7 summarizes the test results for the causality between the black market exchange rates. We choose the optimal lag according to two criteria. Although both are stated in the table, for the sake of simplicity, we will focus on the results based on the lags chosen by AIC criteria. For most of the cases the conclusions drawn do not change much anyway. The black market exchange rates for USD Granger cause the black market exchange rates for EUR and RUB. However, the causality from EUR and RUB to USD is not as strong as the other direction (p-values 0.11 and 0.04, respectively). Between RUB and EUR, causality runs in both directions.

Table 4.7: Causality among Black Market Exchange Rates

	AIC			LR		
H_0	F-Stat	p-value	k	F-Stat	p-value	k
BMUSD $\not\Rightarrow$ BMEUR	12.86	0.00	3	12.86	0.00	3
BMEUR $\not\Rightarrow$ BMUSD	2.06	0.11		2.06	0.11	
BMUSD $\not\Rightarrow$ BMRUB	10.41	0.00	5	5.97	0.00	9
BMRUB $\not\Rightarrow$ BMUSD	1.30	0.27		2.00	0.04	
BMRUB $\not\Rightarrow$ BMEUR	9.07	0.00	2	4.26	0.00	6
BMEUR $\not\Rightarrow$ BMRUB	15.02	0.00		5.64	0.00	

Note: AIC, LR and SIC are used to determine the optimal lag length. k is the optimal number of lagged. $\not\Rightarrow$ stands for "does not Granger Cause."

Table 4.8 summarizes the test results for the causality among national bank exchange rates. It seems like there is mutual causality for all pairs of foreign currencies. This should not be surprising since the official exchange rates are determined as function of a basket of foreign currencies.

Table 4.8: Causality among National Bank Exchange Rates

	AIC			LR		
H_0	F-Stat	p-value	k	F-Stat	p-value	k
NBUSD $\nRightarrow$ NBEUR	2.30	0.02	9	1.72	0.03	27
NBEUR $\nRightarrow$ NBUSD	3.23	0.00		2.25	0.00	
NBUSD $\nRightarrow$ NBRUB	1.61	0.20	2	3.23	0.00	30
NBRUB $\nRightarrow$ NBUSD	11.96	0.00		3.64	0.00	
NBRUB $\nRightarrow$ NBEUR	3.29	0.00	8	2.12	0.01	21
NBEUR $\nRightarrow$ NBRUB	1.87	0.07		1.76	0.03	

Note: AIC, LR and SIC are used to determine the optimal lag length. k is the optimal number of lagged. $\nRightarrow$ stands for "does not Granger Cause."

Next, we summarize the results for Bloomberg exchange rates in Table 4.9. The results are quite similar to the NB rates with one difference that the causality from USD to EUR is not as strong as in National Bank.

Table 4.9: Causality among Bloomberg Exchange Rates

	AIC			LR		
H_0	F-Stat	p-value	k	F-Stat	p-value	k
BUSD $\nRightarrow$ BEUR	1.32	0.20	16	1.44	0.12	28 1
BEUR $\nRightarrow$ BUSD	4.95	0.00		3.04	0.00	
BUSD $\nRightarrow$ BRUB	2.11	0.01	30	1.78	0.03	28
BRUB $\nRightarrow$ BUSD	14.55	0.00		9.23	0.00	
BRUB $\nRightarrow$ BEUR	4.13	0.00	30	3.58	0.00	27
BEUR $\nRightarrow$ BRUB	3.91	0.00		3.46	0.00	

Note: AIC, LR and SIC are used to determine the optimal lag length. k is the optimal number of lagged. $\nRightarrow$ stands for "does not Granger Cause."

In the second part of the causality analyisis we examine the relationship between markets for the same currency. Table 4.10 summarizes the test results for the causality between USD exchange rates in the three markets. We do not see any causal relation between NB and BM exchange rates for USD. However, the black market and Bloomberg exchange rates seem to Granger cause each other. The same conclusion is drawn for NB and Bloomberg exchange rates.

Table 4.10: Causality among different markets for USD exchange rates

H_0	AIC			LR		
	F-Stat	p-value	k	F-Stat	p-value	k
National Bank $\nRightarrow$ Black Market	0.77	0.65	9	0.77	0.65	9
Black Market $\nRightarrow$ National Bank	1.62	0.11		1.62	0.11	
Black Market $\nRightarrow$ Bloomberg	1.75	0.16	3	3.06	0.00	27
Bloomberg $\nRightarrow$ Black Market	13.81	0.00		2.30	0.00	
National Bank $\nRightarrow$ Bloomberg	1.75	0.04	25	1.77	0.04	23
Bloomberg $\nRightarrow$ National Bank	14.15	0.00		11.66	0.00	

Note: AIC, LR and SIC are used to determine the optimal lag length. k is the optimal number of lagged. $\nRightarrow$ stands for "does not Granger Cause."

Table 4.11 summarizes the test results for the causality between EUR exchange rates. Based on the results, we can say that there is a strong causal link from BM to NB as well as from Bloomberg to NB. There is also weaker evidence on the causal link from Bloomberg to the black market (p-value 0.09).

Table 4.11: Causality among different markets for EUR exchange rates

H_0	AIC			LR		
	F-Stat	p-value	k	F-Stat	p-value	k
National Bank $\nRightarrow$ Black Market	0.61	0.77	8	0.76	0.62	7
Black Market $\nRightarrow$ National Bank	3.92	0.00		3.92	0.00	
Black Market $\nRightarrow$ Bloomberg	0.00	0.97	1	1.12	0.36	30
Bloomberg $\nRightarrow$ Black Market	4.46	0.04		1.52	0.09	
National Bank $\nRightarrow$ Bloomberg	0.57	0.94	24	0.50	0.97	23
Bloomberg $\nRightarrow$ National Bank	24.56	0.00		25.04	0.00	

Note: AIC, LR and SIC are used to determine the optimal lag length. k is the optimal number of lagged. $\nRightarrow$ stands for "does not Granger Cause."

As can be seen in Table 4.12, the black market exchange rates for RUB Granger cause Bloomberg exchange rates and Bloomberg exchange rates Granger cause the NB exchange rates for RUB.

Table 4.12: Causality among different markets for RUB exchange rates

	AIC			LR		
H_0	F-Stat	p-value	k	F-Stat	p-value	k
National Bank $\nRightarrow$ Black Market	1.39	0.25	2	0.03	0.87	1
Black Market $\nRightarrow$ National Bank	1.07	0.35		2.10	0.15	
Black Market $\nRightarrow$ Bloomberg	4.75	0.00	18	3.71	0.00	30
Bloomberg $\nRightarrow$ Black Market	1.28	0.22		0.87	0.65	
National Bank $\nRightarrow$ Bloomberg	0.87	0.63	23	0.87	0.63	23
Bloomberg $\nRightarrow$ National Bank	28.32	0.00		28.32	0.00	

Note: AIC, LR and SIC are used to determine the optimal lag length. k is the optimal number of lagged. $\nRightarrow$ stands for "does not Granger Cause."

4.4 Black Market USD exchange rates in different cities

In the following, we analyze the black market exchange rates for USD for six big cities. More precisely, we are looking at causality relations between Minsk and the 5 next biggest cities. The structure is similar to the preceding sections. First, we test for unit root using ADF test. Then, to take care of structural breaks we apply LM unit root test. Last, using the detrended series we apply Granger Causality test to find causal relationship between cities.

Table 4.13: Testing for Stationarity/Unit Root of BM USD in big cities

	Level	
	statistics	p-value
Minsk	-1.72	0.42
Gomel	-1.98	0.29
Brest	-1.67	0.45
Grodno	-2.01	0.28
Vitebsk	-1.91	0.32
Mogilev	-1.79	0.38

Note: Augmented D-F test.

According to the results in Table 4.13, the unit root hypothesis cannot be rejected for all cities. However, due to the possible structural breaks we apply LM unit root tests to test for unit roots with structural breaks against trend stationary processes. The results for all six cities are given in Table 4.14.

Table 4.14: Two-break minimum LM unit root tests for BM USD series in big cities

Series	k	T_{B1}, T_{B2}	Test-statistics	$\lambda = (T_{B1}/T, T_{B2}/T)$
Minsk	8	23.06, 16.08	-3.7654	(0.30,0.56)
Gomel	3	22.05, 12.08	-4.7128	(0.18,0.70)
Brest	0	24.05, 10.08	-4.0067	(0.16,0.58)
Grodno	8	20.05, 15.08	-4.1678	(0.17,0.72)
Vitebsk	8	24.05, 15.08	-4.3336	(0.18,0.72)
Mogilev	8	17.05, 10.08	-6.5550**	(0.14,0.73)

Note:k is the optimal number of lagged first-difference terms included in the unit root test to correct for serial correlation. T_{B1} and T_{B2} are the estimated break dates. λ is the location of the breaks within the sample for which critical values are determined. Critical values are reported in Table 1 of Strazicich, Lee, and Day (2004). ***, ** and * indicate significance at the 1, 5 and 10% levels, respectively.

Results of two-break minimum LM unit root tests for BM USD series in big cities are given in Table 4.14. For the five biggest series we cannot reject unit root at all meaningful significance level. For the series for Mogilev the unit root hypothesis is rejected at a 5% significance level. The plots of these series along with estimated break dates are given in Figure 5.

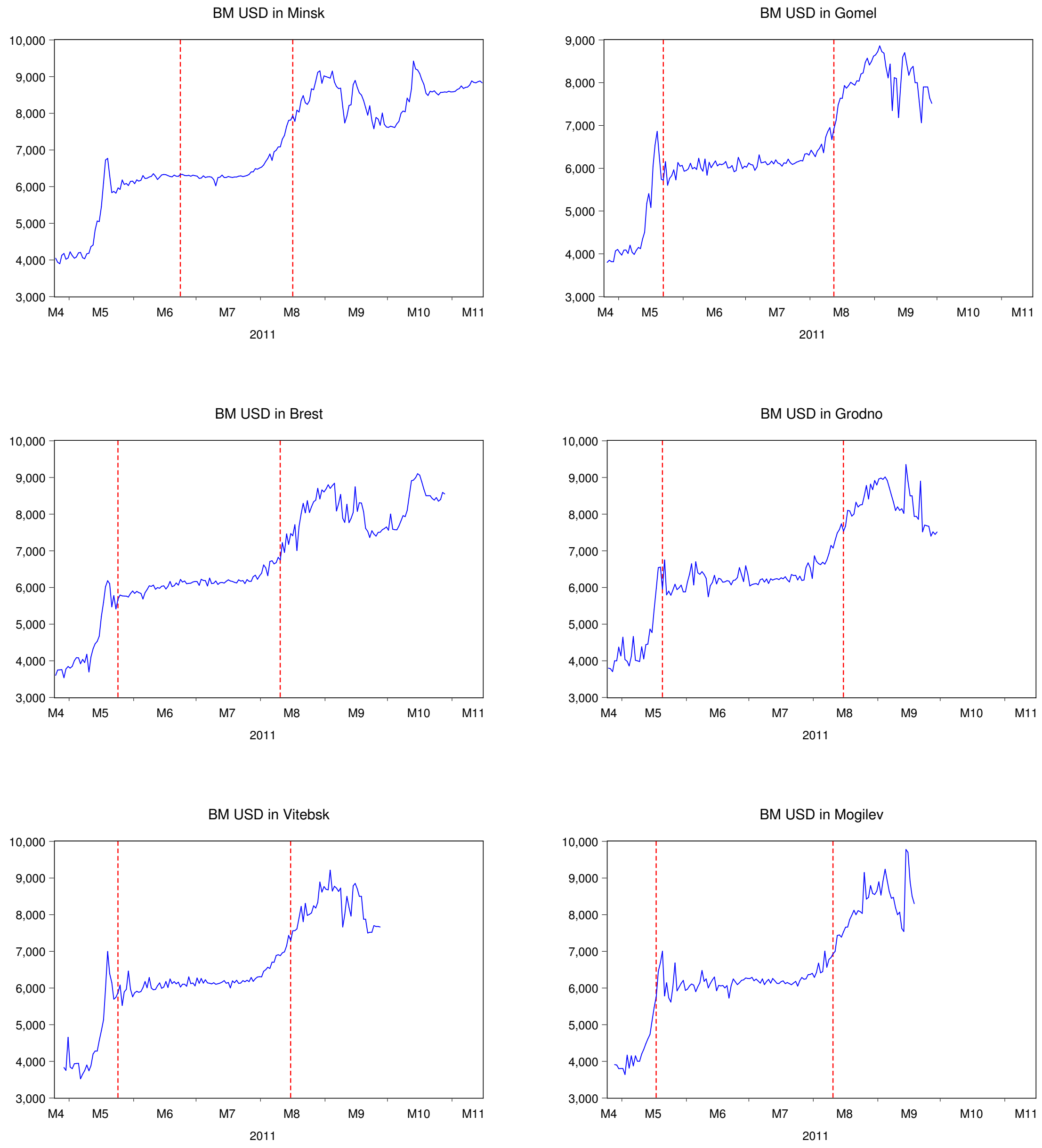

Figure 4.5: Exchange rates and Estimated Break Points: Vertical (red) dashed lines are estimated break points.

Based on these results, we detrend these series by taking the first difference and estimating as in Equation 4.4.

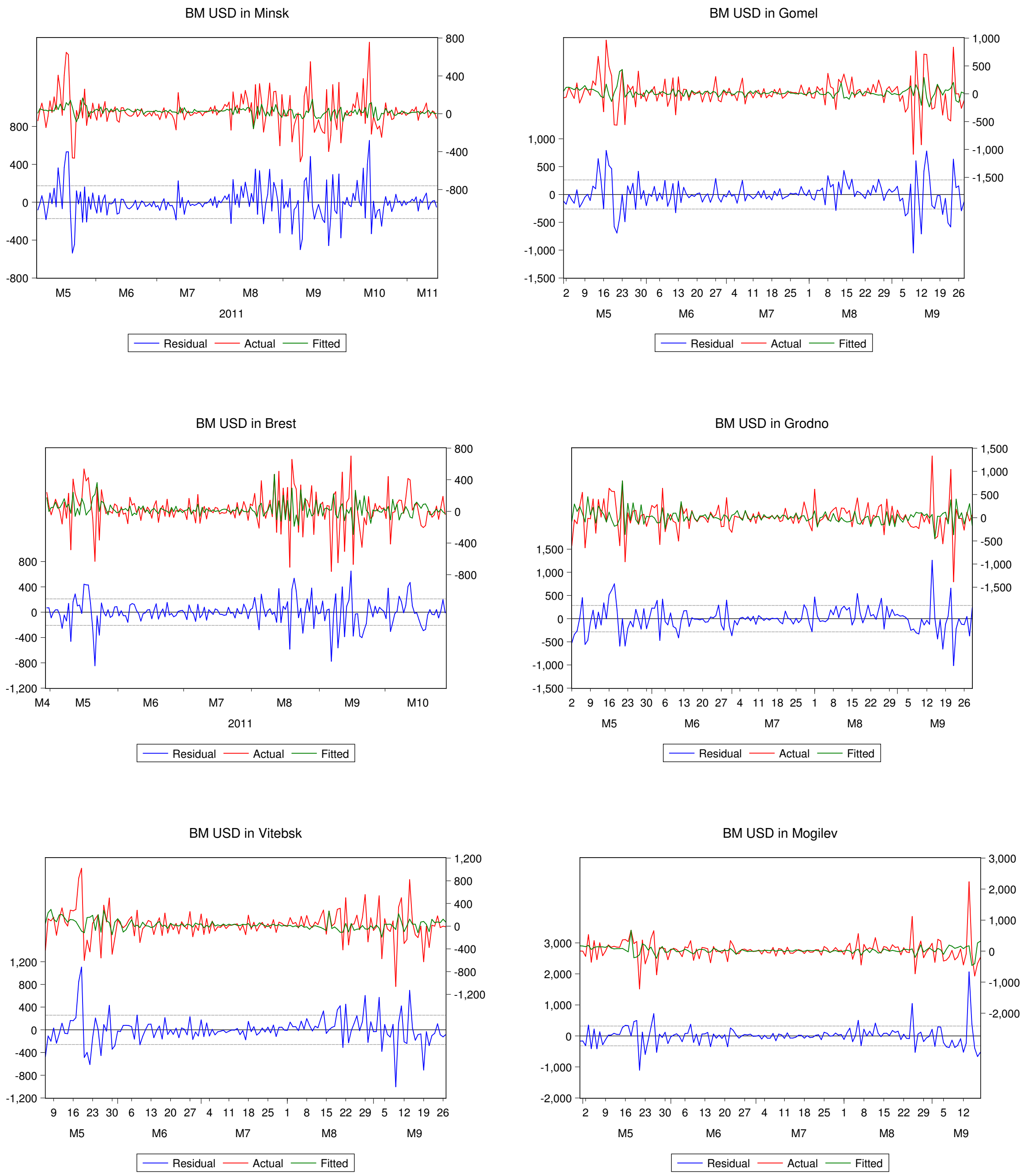

Figure 4.6: Detrended Series: The Regression equations are given in equation 4.4.

Table 4.15: Causality among different cities for USD exchange rates

	LR			AIC		
H_0	F-Stat	p-value	k	F-Stat	p-value	k
Minsk $\nRightarrow$ Gomel	4.86	0.00	29	7.55	0.00	16
Gomel $\nRightarrow$ Minsk	1.83	0.02		3.78	0.00	
Minsk $\nRightarrow$ Brest	2.25	0.00	21	8.12	0.00	5
Brest $\nRightarrow$ Minsk	2.11	0.01		2.22	0.06	
Minsk $\nRightarrow$ Grodno	3.19	0.00	27	3.19	0.00	27
Grodno $\nRightarrow$ Minsk	1.15	0.32		1.15	0.32	
Minsk $\nRightarrow$ Vitebsk	2.33	0.00	22	2.33	0.00	22
Vitebsk $\nRightarrow$ Minsk	1.33	0.18		1.33	0.18	
Minsk $\nRightarrow$ Mogilev	4.68	0.00	15	3.46	0.00	21
Mogilev $\nRightarrow$ Minsk	1.43	0.15		1.46	0.12	

Note:LR, AIC and SIC are used to determine the optimal lag length. k is the optimal number of lagged. $\nRightarrow$ stands for "does not Granger Cause."

Table 4.15 indicates that we always reject the hypothesis that the black market exchange rates for Minsk Granger do not cause the exchange rate in smaller cities. For the second and third biggest cities, Gomel and Brest, there is statistical evidence that the causality is in both directions. However, for the other three cities there is no statistical evidence for causality from smaller cities to Minsk. Unfortunately, we cannot repeat this analysis for other currencies, since disaggregation of the data by cities would lead to time series with too many missing observations.

5 Conclusion

We investigate the causal relation between black market and official rates during the foreign exchange crisis in Belarus. Due to extraordinary economic conditions in Belarus and the unusual webbased Black Market our study differs from previous studies on the same relationship. The unusual nature of this black market could help us identify the effect that technology has had on the relationship between black market and official rates increasing the size of the market and making the information publicly available. However, other things happened during the same period, which may have had an effect, too.

During the time interval under consideration Belarus experienced two devaluations, a period with fixed exchange rates in two segments and an exchange rate regime change. Due to these events it is very likely that there exist structural breaks. In our econometric analysis we take care of the possibility of structural breaks by endogenously determining the break dates for all currency exchange rates. We show that there are different causal relationships in different markets among foreign currencies. Although in the black market, the US dollar seems to affect other currencies but not the other way around, in the two other markets, i.e. in two segments of the official market, the causality is in both directions. If we look at the causal relation between different markets for each currency separately, we see that national bank exchange rates do not cause the black market exchange rates for any currency. For each of the three currencies, the empirical evidence suggests that Bloomberg exchange rates cause the NB exchange rates. Other causality results differ between currencies. We also investigate the causal relation between the black market US dollar exchange rate in the biggest cities. Our results clearly show that the black market exchange rates in Minsk, the biggest city and the center of economic activity in Belarus, causes the BM exchange rates in other cities.

Reinhart and Rogoff (2004) document that in many countries with foreign exchange regimes officially labeled as a "peg," black markets were dominant compared to official markets. They suggest that these regimes should more naturally be labeled as managed or freely floating, or even as "freely falling." We make a similar obervation for Belarus: the internet has helped create a black market that may have made the peg almost meaningsless. Other studies (Gwartney, Lawson, and Easterly, 2006; Shleifer, 2009) have shown that black market exchange rates have nearly vanished since the 1980s, which can be interpreted as a sign of financial liberalization. In October 2011, Belarus has abandoned its foreign exchange rate controls, too. It seems, however, not quite plausible that this meant real liberalization. Reinhart and Rogoff (2004) argue that many exchange rate regimes officially labeled as "freely floating" would more naturally have to be labeled as "managed float" because of central banks' efforts to keep exchange rates within tight bands. Indeed, the official exchange rates of the Belarusian ruble have not been very volatile since October 2011, either. The question is just, for how long the Belarusian central bank will be able to keep the ruble's exchange rates within these ranges.

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