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AN ANALYSIS OF CENTRAL BANK INTERVENTIONS ON FOREX MARKET FOR THE POST-CRISIS PERIOD

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AN ANALYSIS OF CENTRAL BANK INTERVENTIONS ON FOREX MARKET FOR THE POST-CRISIS PERIOD

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Abstract

In this paper, we investigate the determinants of foreign exchange operations of the CBRT for the post-crisis period. Using modern time series econometrics, we try to analyze the different characteristics of FOREX market, and based on the estimation results, indicate the degree of effectiveness of the interventions of monetary authority throughout the implicit inflation targeting framework. The main policy conclusion is that the CBRT interventions seem to be under the control of uncertainties in economic environment, rather than decreasing the volatilities in exchange market, and this case in turn leads the interventions being inefficient.

1. INTRODUCTION

The role of central bank interventions is of crucial importance in an inflation targeting framework. As a developing country case, the Turkish experience on this issue for the post-crisis period associated with the acceptance of independency of central bank constitutes a major policy research area to appreciate the *ex-ante* reasons and *ex-post* consequences of the monetary authorities' policy decisions.

If we begin our analysis by giving a brief account of the Turkish economy, during the 1990s, one of the dominant factors identifying the Turkish economy is the acceptance of the deficit financing policies based on rolling-over the accumulated debt stock giving rise to high volatilities in the domestic interest structure of the economy and this process coincides with the widespread role of the public sector on money markets.[1] In this situation, as Ertuğrul and Selçuk (2001: 18-20) specify, high

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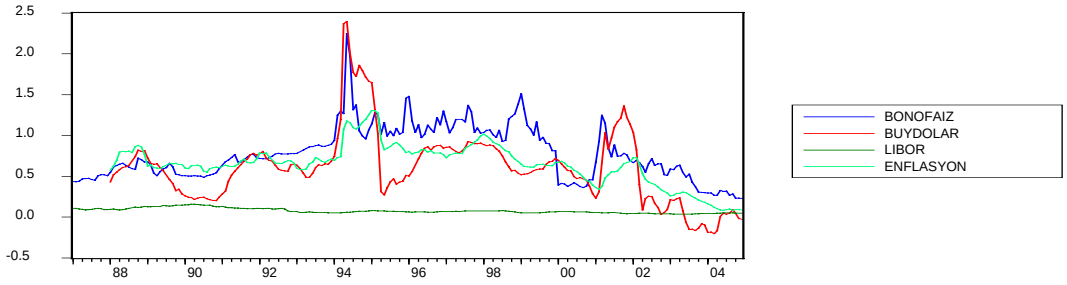
[1] Ersel (1996: 45-64) attributes these policies to a rational Ponzi game in the sense that the governments as a borrower can perpetually roll over their debt without paying either interest or principal, and play this game irrespective of the circumstances in which the public sector finds itself, provided the number of lenders is infinite. He also relates this case to the post-1989 capital account liberalization period which is considered not an economic but a political decision, and expresses that

interest rate commitment on domestic assets, lower depreciation rate and increases in public sector borrowing requirement built up the foreign exchange reserves of the central bank, but also opened up the banking sector, which was exposed to large short positions in terms of foreign currencies supported by high returns on domestic currency based assets, to speculative attacks of hot money. This case also raised the question of whether these policies, based on some form of soft pegs or real exchange rate targeting policies using a managed float system of exchange rate determination supported by short-term arbitrage possibilities, can be carried on towards the future periods.[2]

We below present some stylized facts leading to or led by this hot money phenomenon as one of the dominant characteristics in Turkish economy. We compare in Figure 1 the maximum rate of interest on Treasury bills *(BONOFAIZ)* whose maturity are at most twelve months or less, the annualized inflation rate *(ENFLASYON)* based on consumer price index *(CPI)* with the base year 1987: 100, London interbank yearly offer rate *(LIBOR)* as the foreign opportunity cost under the assumption of open economy conditions and the annualized depreciation rate on nominal exchange rate of TL/US$ *(BUYDOLAR)*. All the data are from the electronic data delivery system of the CBRT.

FIGURE 1: Comparison of Some Stylized Facts



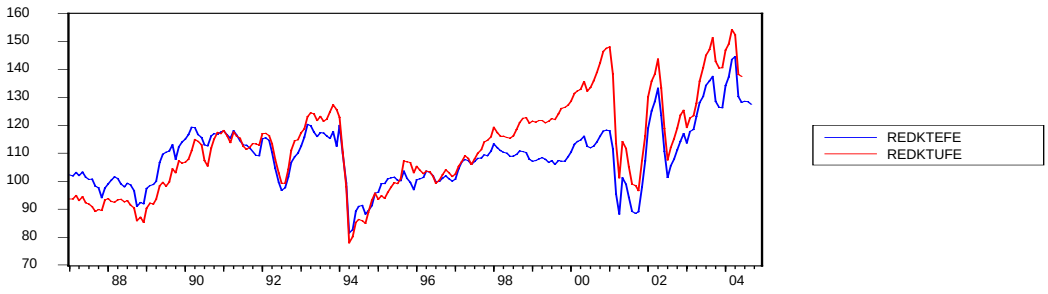
1994 economic crisis had occured due to the violation of its existence condition, when the number of lenders had become finite in a rational Ponzi game perspective, leading to the criticism of the early liberalization of the capital account at least in economic sense.

[2] Özatay (1996: 21-38) and Özatay (1999: 327-352) relate this hot money phenomenon to the 1994 crisis, whilst Özatay (1997: 661-681) emphasizes the non-coordination between the fiscal and monetary policies and also the unsustainable characteristics of fiscal policies for the pre-crisis period. He alleges that this crisis was resulted from policy mistakes of policy makers in Turkish economy in the sense that when no corrective fiscal measures were taken, domestic debt finance had to be continued to maintain the level of inflation and high reserves accumulated up to that time. However, at the end of 1993 the efforts of policy makers in order to change this financing mechanism of deficits by cancelling short maturity domestic debt auctions in favor of relying upon central bank resources heavily led by domestic credit expansion of the Central Bank just prior to the burst of the crisis, i.e. monetization, were significant policy mistakes leading to the crisis conditions. He concludes that despite the weak fundamentals in the economy, had there not been policy mistakes such as canceled auctions, fixing the upper limit or offering small amounts, the financial crisis could have been avoided. Celasun (1998) indicates some evidence of monetization for the pre-crisis period of 1994 and expresses the uncontrollably growing domestic debt stock as the main underlying reason behind the crisis of 1994, whilst Alper and Sağlam (2001: 29-48) examine the real output effects of the crisis under various monetary transmission mechanisms. From a different perspective of radical political economics, Yeldan (1996: 427-476) attributes the crisis conditions to some socio-economic class conflicts resulted from distributional issues of national income.

Figure 1 points out that throughout almost whole 1990s beginning from 1989 in which capital account liberalization was completed and capital inflows by non-residents in order to invest in Turkish securities and government bonds were permitted as well as capital outflows by residents in an unfettered way under no control of fiscal or monetary authority, the return on TL denominated assets is above the depreciation rate of nominal exchange rate and there also exists an enormous difference between the domestic and foreign interest rates as well as a paralel movement between domestic inflation and interest rate and nominal exchange rate recalling some form of UIP and PPP hypothesis.

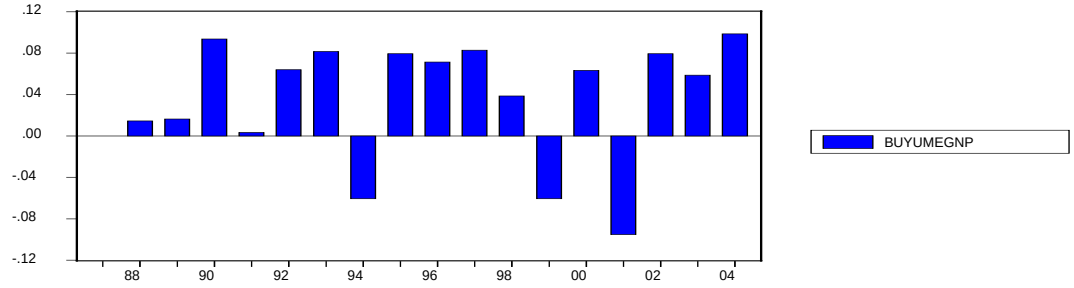
Besides, in Figure 2 we give the real exchange rate indices based on consumer prices *(REDKTUFE)* and producer prices *(REDKTEFE)* with the base year 1995: 100 which are calculated by the CBRT with the weights used for 19 countries (Germany, USA, Italy, France, United Kingdom, Japan, Netherlands, Belgium, Switzerland, Austria, Spain, Canada, Korea, Sweden, Taiwan, Iran, Brazil, China and Greece) by the IMF. An increase in these indices denotes an appreciation of the Turkish Lira, whereas a decrease denotes a depreciation. Beginning in 1989 onwards, a steadily upward trend can easily be seen in these indices except the 1994 and post-2001 crisis periods. When thought of together with Figure 3 in which we give the annual growth rates in real gross national product *(BUYUMEGNP)* for Turkish economy, the larger the interest rate differential and the more the difference between the domestic borrowing and nominal depreciation rate also recalling hot money phenomenon, the larger would be the annual growth rate of real domestic income and vice versa.[3]

FIGURE 2: Real Effective Exchange Rate Indices



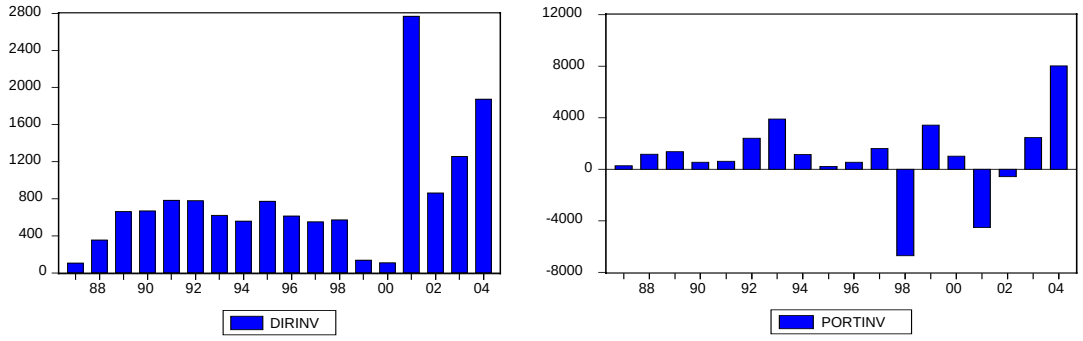
[3] Erol (1998: 275-296) reveals how the real exchange rate policy is depended upon real interest rates for Turkish economy. Togan and Ersel (2004) relate the real effective exchange rate policy of Turkey to the subject of current account sustainability for both 1980s and 1990s also considering the developments in the post-2000 period, whilst Özlale and Yeldan (2004: 1839-1849) examine the real exchange rate of Turkish economy for the post-1994 period and give evidence, contrary to common belief, that except the initial four months of the 2000-stabilization program the Turkish Lira remained structurally undervalued for most of 2000. Akçoraoğlu (2000: 21-36) finds evidence in favor of that the liberalization of capital flows for the post-1989 period has become a major cause of current account instability in Turkish economy, whilst İnsel and Sungur (2003) estimate that this process leads to uncertainties and increases the volatilies of real and financial indicators in the economy. Also Berument and Paşaoğulları (2003: 401-435) point out the contractionary impact of real exchange rate depreciations on output for the post-1987 period, rather than the reverse case. On the other hand, İsmihan, Metin-Özcan and Tansel (2005: 239-252) interest in the issue of macroeconomic instability on income generation process and on public and private investment climate. Their estimation results imply that macroeconomic instability had been very costly in terms of capital accumulation and economic growth during the chronic instability episode of Turkey.

FIGURE 3: Annual Growth Rates of Real GNP

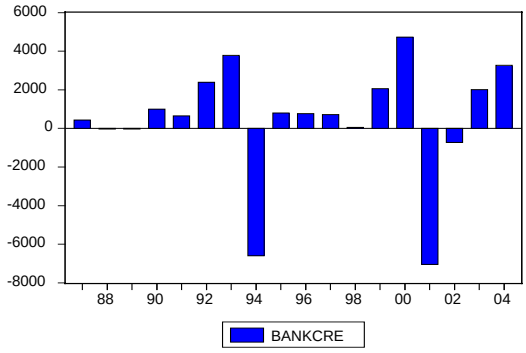


As an other supporting argument to the findings above, in Figure 4 we examine the sub-determinants of capital flows experienced in Turkish economy in millions of US$s. Below *DIRINV* is the foreign direct investments net of direct investment in Turkey and direct investment abroad, *PORTINV* is the portfolio investments net of assets and liabilities as equity securities and debt securities and *BANKCRE* is the short term capital movements through banking sector as the difference between the loans received and repayments. All the data are taken from the electronic data delivery system of the CBRT. As can easily be noticed in Figure 4, the periods of appreciating real exchange rate and growing real domestic income and also the periods in which the difference between the returns of TL denominated assets and nominal exchange rate grows, coincide with large capital inflows through increases in bank credits net of loans received and repayments and increases in portfolio investments, whilst decreases in these components of capital flows give rise to opposite changes in real effective exchange rate, real domestic income growth rate and the difference between the returns of TL denominated assets and nominal exchange rate in a chronical two-digits inflationary framework.[4] These processes led by the dominant characteristics of hot money phenomenon seem not to be changed in the economy for the post-2000 period.

FIGURE 4: Determinants of Capital Flows



[4] Balkan, Biçer and Yeldan (2002) give a comprehensive analysis of hot money phenomenon for Turkish economy. Agénor, McDermott, and Üçer (1997) point out that positive shocks to the uncovered interest rate differential lead to a capital inflow resulted in appreciation of the real exchange rate, whilst Gümüş (2002) finds evidence in favor of that interest rate defense had not been successful in appreciating the exchange rate in the 1994 Turkish crisis. Kirmanoğlu and Özçiçek (1999: 27-34) estimate that capital inflows temporarily lower the interest rates and promotes business investment and growth. Besides, there exists an appreciating impact of short-term capital flows on Turkish currency which in turn lowers the inflation rate and increases the real wages.

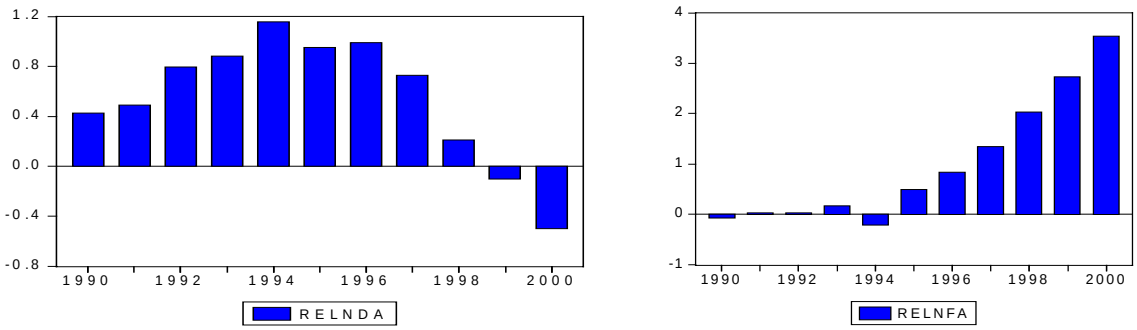


To control or at least to defend the current exchange rate system in this situation may normally be expected that the monetary authority should have enough foreign assets in order to intervene to money markets when necessary. Below we indicate in Figure 5, where *RELNDA* indicates the contribution of net domestic assets to central bank money and *RELNFA* is the contribution of net foreign assets to central bank money[5], that monetary authority implements a policy change after the period of 1994 economic crisis in the sense that the behaviour of the CBRT in creating monetary base or central bank money significantly changes and tends to accumulate net foreign assets as a reaction to highly volatile capital outflows leading to exchange rate crisis such as the case of 1994 economic crisis, thus aiming to provide stability in financial markets[6], whilst trying to restrict the growth rate of net domestic assets. Here we restrict ourselves for the pre-2001 period due to definition changes in the CBRT's balance sheet items since then.

[5] The net domestic assets consist of sum of the Treasury's debt resulted from credits granted to public sector, credits to banking sector, and other items excluding FX revaluation account. We should specify that for the post-2001 period, through the amendment of the CBRT Law on April 22 2001, the granting of cash advances to the Treasury and credits to the public institutions was ceased and it was stated by the CBRT that the Central Bank will no longer purchase t-bills from the primary market starting from November 5 2001. On this account, some definition changes in certain balance sheet items were made to provide that the developments in the CBRT's securities portfolio were easily monitored. In this respect, "Credits to the Public Sector (net)" item under Net Domestic Assets has been altered as "Treasury Debt". Prior to November 5 2001, "DİBS prior to Nov. 5 2001" item under "Treasury Debt" has moved due mainly to the direct purchases of the Central Bank in line with the restructuring of the banking system. Following that date, this item has changed mainly because of reverse repo operations and exchange rate differences related to foreign exchange indexed Government Domestic Debt Securities. (CBRT, 2002, April: 29) Net foreign assets are calculated as the difference between total foreign assets and foreign liabilities to non-residents. And CB money under the liability of monetary authority is calculated as the sum of currency issued, deposits of banking sector as required reserves and free deposits, extrabudgetary funds, deposits of non-bank sector, open market operations and YTL deposits of public sector.

[6] Özatay (2000) touchs on a similar subject considering the business cycles and the role of monetary policy in creating structural breaks for Turkish economy in the sense that monetary authority tends to minimize the volatility of overnight interest rates and of exchange rates in order to create a more certain environment to ease the purchase of domestic public debt instruments, which is, in the absence of fiscal discipline, considered as a necessary condition in keeping the high inflation stable.

FIGURE 5: Relative Contribution of Net Domestic and Net Foreign Assets to Central Bank Money



In this framework, Turkish economy experienced an anti-inflationary stabilization program based on a quasi-currency board suggesting exchange of domestic currency against foreign currencies selected on a constant rate of exchange (Özdemir and Şahinbeyoğlu, 2000) in 2000, but this program ended with an enormous economic crisis with a depreciating real income about %9 (see Figure 3 above).[7,8] Following November 2000 - February 2001 crisis, the Turkish economy have been trying to

[7] Ertürk (2003) gives a brief but comprehensive account of such crises based on speculative expectations of capital flows dealing also with sovereign country risks and their reversals through an analysis using uncovered interest rate parity condition.

[8] In the literature on Turkish economy, many studies have been dealed with the Turkish crises of November 2000 and February 2001. If briefly required to touch on the Turkish crises of 2000/01, Uygur (2001) points out various leading indicators of these crises by comparing the Turkish experience of IMF-supported stabilization program with international evidence of such crises. Fischer (2001: 3-24) relates the ensuing of crises conditions to banking sector problems and failures to undertake corrective fiscal actions when the current account widened, whilst Dornbusch (2001) considers the Turkish crises as an example of balance sheet problems in the banking system such that a spell of high interest rates caused the general deterioration of the loan portfolios of the banks leading to withdrawal of international credit lines triggering a banking crisis. Financing the run on the banks by pumping in credit by the central bank to repurchase the liquidity by selling foreign exchange led to reserve depletion threatened the maintenance of IMF supported exchange rate based stabilization program. Eichengreen (2001) deals with some moral hazard problems leading to credibility and coordination problems in implementation of the stabilization program between market participants, policy makers and IMF such as the issues raising doubts about fiscal sustainability in rolling over the short term debt by investors. Gençay and Selçuk (2005) express that one of the lessons from the Turkish crisis is that even if there is no deterioration in the fundamental indicators, the balance sheet issues in the financial sector may create an environment in which even a small shock can lead to a total collapse of the system. In particular, a balance sheet mismatch situation (funding long term illiquid assets with short term obligations) combined with slack supervision and regulation is an invitation for a liquidity and currency crisis. Alper (2001: 51-71) argues that inability of the Turkish government in maintaining the stream of good news and sustaining capital inflows, lack of enough backing of the program by the IMF in terms of providing sufficient insurance against exchange rate risk and existence of the no sterilization rule which was argued to be a design flaw in the program since it led to interest rate undershooting initially were amongst the main factors contributed to the creation of the 2000 liquidity crisis, and expresses that these facors which were coupled with the fragile structure of the banking system helped bring about the events that led to the following crisis at the end of February 2001. Alper and Öniş (2002a) emphasize the political fragility of the stabilization program with a half-hearted commitment by policy makers in giving sufficient insurance and support in implementation of the program, in addition to some deficiencies or dilemmas in construction of the

establish a free-floating exchange rate system, and in this perspective, the role of monetary authority seems to be changed dramatically from an accommodative role responsive to some endogeneous factors especially to domestic interest structure of economy and to real exchange rate determination towards a price stability framework as a main policy target.[9]

2. IMMEDIATE POLICY DEVELOPMENTS FOR THE POST-CRISIS PERIOD

Having considered some developments of the pre-2001 period in Turkish economy as expressed above, we now aim to shed light on the policy interventions of the CBRT for the post-2001 period of floating exchange rate regime, and try to analyze the Turkish experience. For this purpose, we will use the official reports published by the CBRT in order to bring out *ex-ante* expectations dealing with such policy interventions, and will be interested in *ex-post* results of these expectations based on some

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program. In this sense, that the program relied heavily on the availability of short term capital inflows in a sustained basis given the uncertain environment within which the program was introduced, giving too much emphasis by IMF to that institutional engineering would work and independent regulatory agencies could be smoothly instituted without paying much attention to domestic political process leading to significant delays in struggling the ensuing problems, and inherent problems of the exchange-rate based anti-inflationary programs such as exit strategies were amongst the main reasons of crisis conditions, whilst Alper and Öniş (2001) attribute the ensuing of the crisis conditions to that these crises were mainly a reflection of the populist cycles in the post capital account liberalization period of Turkish economy led by various deficit sustainment policies which were subject to over-dependence upon short term capital flows in a financial globalization environment. These all were also related to the weak democratic framework dominated in the country which was feeded by limited accountability and transparency of the state and other political institutions. Alper and Öniş (2002b) and Alper, Berument and Malatyalı (2002: 167-181) give special emphasis to the developments in Turkish banking sector in analyzing the crisis conditions. On the other side, Akyüz and Boratav (2001) express that the program was so designed that there was little policy space left for corrective macroeconomic actions, particularly in the face of widening current-account deficit. In this sense, they allege that the stabilization program failed and the crisis deepened in large part because of serious shortcomings in its design and implementation as well as in crisis management such as the lack of overhauling the banking system before launching the program, inability to apply some market-based restrictions over arbitrage flows, agreement upon a monetary policy by currency board and non-sterilization rule which was excluded from giving support against the capital flows, internal inconsistencies of the IMF giving a great share of responsibility onto the government leading the program to be counter-productive instead of achieving sound monetary, fiscal and exchange rate policies along with institutional underpinnings. Yeldan (2001) takes into consideration the increased fragility in the financial system led by uncontrolled and excessively volatile capital flows with an exceedingly speculative ("hot") component as the main cause of crisis, whilst Ertuğrul and Yeldan (2002: 53-67) highlight the structural weakness of the exchange rate backed disinflation program as manifested in its liquidity creation mechanism in a small and fragile financial system such as Turkey. Ekinci and Ertürk (2004) also express that the design of the stabilization program lacked any provision to cope with the portfolio dynamics driven by the speculative asset price expectations it had generated such that the real cause of the capital reversal leading to crisis conditions was profit taking on the part of foreign speculative investors holding government securities who conjectured that falling interest rates had reached their limit.

[9] For some criticism of these factors in this perspective and the main properties leading Turkish economy to 2000 stabilization attempt throughout the 1990s, see Akat (2000) and Ertuğrul and Selçuk (2001: 6-28).

forms of modern time series estimation techniques in the following sections after presenting some literature review upon Turkish economy.

As of the beginning of floating exchange rate system the CBRT designed its monetary policy in order to cease the problems in payments system and to maintain stability in the financial markets. Within this framework, the CBRT provided the required liquidity through quotations and open market operations in the form of direct purchases, and supplying the Turkish lira at the interbank money market. In order to bring functionality to the banking system and to end the bottleneck at the payments system, the CBRT actively intervened in the markets, lowered the short term interest rates, and implemented policies to provide the efficient allocation of the liquidity in the system. The maturity of the overdue repos of the state banks and the banks under the Saving Deposits Insurance Fund (SDIF) was renewed so that the pressure of these banks to the system was depressed (CBRT, 2001, November: 19). Besides, some ceiling values to the net domestic assets and the base money items of the CBRT balance sheet, and floor values to the changes that can periodically be realized in the net international reserves had been set. But, as a difference from a strict monetary targeting framework, the restriction on the base money was not a performance criterion but an indicative ceiling value (CBRT, 2001, November: 3), since the crisis environment and rapid structural changes in financial markets led to structural changes in the money demand and base money estimations. And this policy framework has been aimed to be carried on until the prerequisites for inflation targeting regime would be met (CBRT, 2002, April: 18). Also in order to rehabilitate the financial structure of state banks and fund banks, the Treasury provided new T-bills to these banks, of which a considerable amount was purchased directly by the CBRT. This liquidity enabled state banks and fund banks to close their overnight borrowing to other banks and to their customers. The excess liquidity due to this transaction as well as the liquidity expansion due to use of external financing provided from the IMF in the domestic financing was withdrawn by the CBRT through FX sales, reverse repo and interbank transactions. The effect of domestic credit expansion on monetization as a result of these operations was controlled by the CBRT, maintaining the base money as predicted by the program, and thus limiting its inflationary consequences (CBRT, 2001, November: 19-21).

In this policy framework, the exchange rate policy was based on the principle of the determination of exchange rate according to the supply and demand conditions in the market. Interventions to the foreign exchange would be limited and the CBRT would intervene in the foreign exchange market in order to prevent excessive fluctuations. If required, the CBRT would use transparent methods destined to increasing foreign exchange reserves in compliance with the floating exchange rate regime without distorting the long term trend of exchange rate and its natural equilibrium point. In this respect, whilst the CBRT conducted regular auctions of sale of foreign exchange in order to smooth the effects of short term temporary exchange rate fluctuations without affecting the long run equilibrium level, and to sterilize the excess liquidity in the market caused by the use of external financing in the very early

phases of the program throughout 2001 (CBRT, 2001, November: 24), subsequent phases witnessed FX purchase auctions to accumulate reserves and to strengthen the confidence in the markets in the medium and long run (CBRT, 2002, April: 19).

Also, in the aftermath of the February 2001 crisis, short term interest rates had been used to provide price stability and determined considering the developments in inflation and the developments in the macroeconomic variables affecting future inflation. Thus, the CBRT would cut its short term interest rates considering the developments in domestic economy, such as appreciation of Turkish lira, absense of a revival of the domestic demand that might have a boosting effect on inflation, public price movements in accord with year-end inflation target, the convergence of inflation expectations towards year-end target, and decreasing of volatilities in financial markets (CBRT, 2002, July: 25; CBRT, 2002, October: 20-21). Naturally, the reverse developments to those considered above would lead the CBRT to implement different policies in conduct of monetary policy.

In line with these issues, the CBRT recently announces that monetary policy have been implemented in light of the purpose of price stability by the second quarter of 2005. Developments in capital, money and exchange rate markets as well as developments in aggregate supply-demand equilibrium, productivity, employment, unit-wage costs, public and private sector pricing behaviour, and also changes in inflation expectations and some risk considerations led by exogeneous shocks in international markets will be considered in implementing the monetary policy (TCMB, 2005, Temmuz: 27-30). Thus a higly endogeneous characteristics at least in the *ex-ante* formation process of policies and expectations seem to have a dominant role by the CBRT. So the CBRT warns against some developments resulted from external political factors also interested in Turkish foreign policy, leading to increases in the risk premium in determination of market interest rates, and declares that it will try to make policy considerations by acting more prudently as to the past in light of these developments. In this respect, by the second quarter of 2005, no change has been decided dealing with short term interest rates.[10]

3. LITERATURE REVIEW UPON TURKISH ECONOMY

As expressed above, the CBRT announced that for the post-crisis period interventions to the foreign exchange market would be limited and that in implementing such kind of interventions the CBRT would aim to prevent excessive fluctuations as a primary goal. In this section, we try to give some literature review upon this subject trying to explore how successful is the CBRT in this subject. Considering the Turkish economy as a case study, Ağcaer (2003), Domaç and Mendoza (2004),

[10] Özdemir and Turner (2005) recently warn that in line of above statements policy makers should pay attention to the importance of fiscal discipline to achieve the objectives such as to sustain the disinflation process and to reduce the high budget deficit in Turkey. In the long term perspective, they conclude that tight fiscal policies should be mixed with either monetary or debt management policy to avoid the excessive monetary contraction as the real demand for broad money increases with the disinflation process.

Selçuk and Ardıç (2005), Selçuk (2005: 295-312) and Ardıç and Selçuk (2005), Guimarães and Karacadağ (2004), Herrera and Özbay (2005), Akıncı, Çulha, Özlale and Şahinbeyoğlu (2005a) and Akıncı, Çulha, Özlale and Şahinbeyoğlu (2005b) recently try to analyze how the foreign exchange market responses to central bank interventions in a floating exchange rate system.[11]

In special case of Turkish economy, Ağcaer (2003) estimates that the CBRT's interventions as a whole are effective in reducing volatilities in exchange rates, and that in affecting the level of exchange rates, larger amounts interventions in a lower frequency are more effective, whilst smaller amounts interventions in a higher frequency seem to be more effective in reducing volatilities especially through sale interventions. Akıncı, Çulha, Özlale and Şahinbeyoğlu (2005a) investigate the impact of the foreign exchange interventions in different perspectives. They find that higher volatility in exchange market leads to higher probability of intervention, and higher depreciation (appreciation) trend in Turkish lira means higher probability of sale (purchase) intervention. Also, as a result of causal relationships, interventions in the foreign exchange market seem to signal the future course of monetary policy, and lead to changes in volatility in the foreign exchange market. A detailed investigation of central bank interventions gives some evidence to the effectiveness of purchase interventions on the volatility of exchange rate, rather than the sale interventions. Akıncı, Çulha, Özlale and Şahinbeyoğlu (2005b) support these findings in the sense that purchase-based interventions seem to be successful especially after the financial markets are stabilized, and propose a policy implication that the CBRT should not hesitate to intervene in the market in the form of large purchases. They also find that uncovered interest rate parity condition operates in an unconventional way such that a decrease in the secondary market interest rates leads to a further appreciation of the Turkish lira as a result of the decrease in the perceived risk of the foreign investors.

Domaç and Mendoza (2004) estimate that whenever the exchange market perceives the presence of the central bank, domestic currency inclines to be appreciated, and rather than the purchase operations the sale operations seem to be effective on the mean level of the exchange rate. Interventions reduce the volatility of exchange rate through the sale operations. As a monetary policy instrument, an increase in overnight interest rates leads to decreases in volatility. They report that if the foreign exchange interventions are carried out with finesse and sensibly, i.e., not to defend a particular exchange rate, they could play a useful role under an inflation targeting framework in containing the adverse effects of temporary exchange rate shocks on inflation and financial stability.

Selçuk and Ardıç (2005), Selçuk (2005: 295-312) and Ardıç and Selçuk (2005) analyze the dynamics of exchange rate in Turkey in the aftermath of recent float in February 2001. Their findings generally point out that the central bank policies are effective in taming the volatility of exchange rate

[11] Sarno and Taylor (2001: 839-868), Canales-Kriljenko, Guimarães and Karacadağ (2003) and Ağcaer (2003) consider the policy issues and surveys of methodologies dealing with foreign exchange interventions, and give international evidence on the effectiveness of such kind of interventions.

especially through selling auctions. Besides, unexpected increases in interest rates raise volatility, which makes it possible to say that unexpected interest rate cuts reduce the volatility of exchange rate. Thus, they conclude that these findings are in line with the CBRT's official argument that its policies are not aimed at the level or the direction of the exchange rate but rather the goal is to contain volatility. They also warn against the extreme appreciation of domestic currency and record level of real interest rates which give the impression that the current state of economy is fragile.

Herrera and Özbay (2005) find that foreign exchange interventions during the free float period appear not to be effective in altering the exchange rate level, and have only a positive and marginally significant effect on the exchange rate volatility. In this respect, the estimation results reported suggest that foreign exchange sales seem to have a positive but only marginally significant effect on the conditional variance of exchange rate, whilst purchase based interventions have no statistically significant effect on the volatility of exchange rate. Foreign exchange interventions carried out by the CBRT also have no significant effect on the conditional mean of the exchange rate. Considering the free float period, they conclude that the estimated findings are in line with the objective of the CBRT to let the market determine the level of exchange rate, and only intervene during periods of heightened volatility. However, foreign exchange interventions appear to have led to higher, not lower, volatility. Guimarães and Karacadağ (2004) also find that for the case of Turkey neither foreign exchange sales nor purchases have a significant effect on the exchange rate level, whilst only foreign exchange sales (but not purchases) reduce volatility in the short term, but increase it in the long term. Thus, they conclude that the estimated results do not seem to substantiate claims that intervention is a useful tool to smooth volatility.

4. DYNAMICS OF CBRT'S FOREX INTERVENTIONS

The Turkish economy witnessed a highly devastating crisis both on the real income generation process with a %9 rate of depreciation (see Figure 3), and on the financial markets which were subject to a great deal of volatility, and on many socio-economic indicators which made people become poorer. Following the crisis conditions, dealing with the implementation of monetary and exchange rate policy, the officials of the CBRT announced that in conducting the monetary policy the primary goal would be to smooth out the volatilities in these markets, and so intervention policies would be decided on the basis of limiting excessive volatility, or not to follow some strict targets upon the current levels of financial indicators. Indeed, the latter type of policies might lead to some unacceptable *ex-post* policy realizations given the hugh level of debt stock for government and strong sensitivity of financial indicators to domestic interest structure of the economy. Thus, the conduct of monetary policy canalized into a partially accommodative policy stance in the sense that no policy choices increasing the riskiness of domestic borrowing and the risk premium in financial markets could be accepted.

Akin to the monetary policy implementation issues, by the beginning of 2002, the CBRT announced that it was of great importance that the central bank should respond to shocks in exchange rate, wages, and public prices to pave the way to the targeted inflation rate (CBRT, 2002, April: 70). In this respect, the CBRT also accepted that inflationary pressures in Turkish economy had their origin in non-monetary factors such as shocks that lead to sharp exchange rate depreciations, adjustments in the public sector prices, and inflationary inertia.

Through these policy proposals, as of the early phases of post-2001 crisis period, the CBRT has been applying to some intervention policies in foreign exchange market. By the very early phases of post-2001 free floating regime, all interventions tend to be in the form of sale interventions. In this period, the total of foreign exchange sale interventions which were all in 2001 between 29/03/2001 and 30/11/2001 was US$ 6553 million. Beginning in April 2002 up to very recent times of the first half of 2005, all interventions have been in the form of buying interventions. The first part of those was implemented between 01/04/2002 and 27/06/2002, and US$ 795 million was bought back by the CBRT. The second part was between 06/05/2003 and 22/10/2003, and the total amount bought back by the CBRT was US$ 5652.3 million. Also in 2004 and by the first quarter of 2005, the foreign exchange market witnessed two other episodes of buying interventions. The first one running from 23/01/2004 through 26/04/2004 summed up to US$ 3782.4 million, whilst the other running from 22/12/2004 through 01/03/2005 summed up to US$ 2071.7 million. Thus, as of the beginning of free floating period, the total amount bought back by the CBRT through foreign exchange interventions is US$ 12301.4 million.

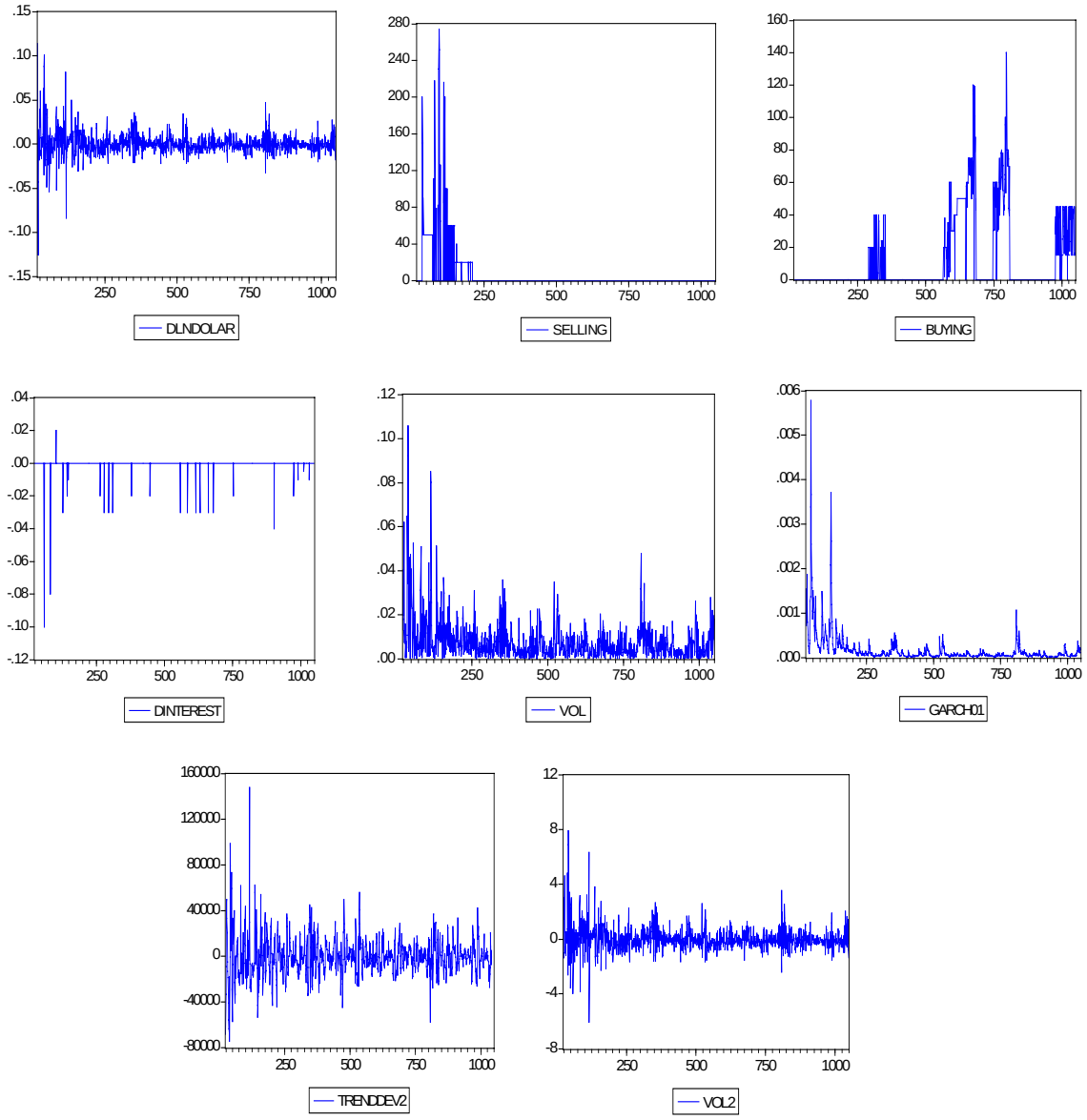
Having examined briefly both the course of monetary policy stance of the CBRT and the intervention policies for the post-2001 period, we will try to examine the possible determinants of foreign exchange interventions. For this purpose, we will first apply to well known generalized autoregressive conditional heteroskedasticity (GARCH) methodology (Bollerslev, 1986: 307-327) in order to reveal the effects of such interventions on the level and volatility of exchange rate return. Then, we will use some unrestricted vector autoregression techniques (VARs) which is to the great extent inspired by Ardıç and Selçuk (2005), Selçuk (2005: 295-312) and Selçuk and Ardıç (2005) in order to reveal the dynamic relationships between applied interventions and their *ex-post* results, so we aim to appreciate whether our findings are consistent with each other giving general conclusions. Our time series representation using daily data begins from 23/02/2001 till 01/04/2005 with a 1034 business days. The variables used are TL / US$ exchange rate return in log difference (DLNDOLAR), the daily total amount sold by the CBRT in US$ selling auctions in millions of US$ (SELLING), the daily total amount bought by the CBRT in US$ buying auctions in millions of US$ (BUYING), the change in central bank overnight interest rates (DINTEREST), the absolute value of exchange rate return as a measure of exchange rate volatility (VOL), conditional variance of exchange rate estimated through using GARCH methodology as a measure of volatility (GARCH01) and the deviation of

exchange rate from its 15 days moving average following Akıncı, Çulha, Özlale and Şahinbeyoğlu (2005) as a measure of volatility (TRENDDEV2) which is calculated as,

$$(TL/US)_i - (1/15).\sum_{t=i-7}^{k=i+7} (TL/US\$)_i \qquad (1)$$

We also consider an exchange rate pressure index (VOL2) calculated as the difference of daily per cent change in exchange rate from its mean value as a measure of volatility, which can be an indicator of the possible intervention policies of the monetary authority. Following Özatay (1999: 327-352), we weighted this pressure index by the inverse of its standard deviation. Using a preliminary investigation not reported here, we have found that all the variables considered are stationary. Also a short glance to Figure 6 below points out that all the variables have stationary characteristics.

FIGURE 6: TIME SERIES USED IN THE PAPER



In Table 1 we reveal the descriptive statistics of the variables. Making use of QMS (2004: 298-300) for these statistics, 'Mean' is the average value of the time series, obtained by adding up the series and dividing by the number of observations. 'Median' is the middle value (or average of the two middle values) of the series when the values are ordered from the smallest to the largest. The median is a robust measure of the center of the distribution that is less sensitive to outliers than the mean. 'Max' and 'Min' are the maximum and minimum values of the series in the current sample. 'Std. Dev.' (standard deviation) is a measure of dispersion or spread in the series. The standard deviation of the times series *'y'* is given by,

$$s = \{ [\sum_{i=1}^{N} (y_i - \bar{y})^2)] / (N-1) \}^{1/2} \quad (2)$$

where *'N'* is the number of observations in the current sample and *'$\bar{y}$'* is the mean of the series. 'Skewness' is a measure of asymmetry of the distribution of the series around its mean. Skewness is computed as,

$$S = (1/N) \sum_{t=1}^{N} [(y_i - \bar{y}) / E(\sigma)]^3 \quad (3)$$

where 'E*(σ)*' is an estimator for the standard deviation that is based on the biased estimator for the variance. The skewness of a symmetric distribution, such as the normal distribution, is zero. Positive skewness means that the distribution has a long right tail and negative skewness implies that the distribution has a long left tail. 'Kurtosis' measures the peakedness or flatness of the distribution of the series. Kurtosis is computed as,

$$K = (1/N) \sum_{i=1}^{N} [(y_i - \bar{y}) / E(\sigma)]^4 \quad (4)$$

where '*E(σ)*' is again based on the biased estimator for the variance. The kurtosis of the normal distribution is 3. If the kurtosis exceeds 3, the distribution is peaked relative to the normal. If the kurtosis is less than 3, the distribution is flat relative to the normal. Finally, 'Jarque-Bera' is a test statistic for testing whether the series is normally distributed under the null hypothesis. The test statistic measures the difference of the skewness and kurtosis of the series with those from the normal distribution. The statistic is computed as,

$$Jarque\text{-}Bera = [(N-k) / 6] [S^2 + (K-3)^2 / 4] \quad (5)$$

where *'S'* is the skewness, *'K'* is the kurtosis, and *'k'* represents the number of estimated coefficients used to create the series. Examining Table 1 points out that log-return of exchange rate has excess kurtosis. Also akin to the findings of Domaç and Mendoza (2004), exchange rate return is biased to the right, and a significant departure from normality is found.

TABLE 1: DESCRIPTIVE STATISTICS

	DLNDOLAR	SELLING	BUYING	DINTEREST	VOL	GARCH01
Mean	0.000378	6.424510	11.89559	-0.000642	0.007656	0.000170
Median	-0.000735	0.000000	0.000000	0.000000	0.005133	6.64E-05
Maximum	0.100510	274.0000	140.0000	0.020000	0.105734	0.005783
Minimum	-0.083600	0.000000	0.000000	-0.100000	0.000000	1.06E-05
Std. Dev.	0.012072	24.81316	23.31589	0.005399	0.009487	0.000367
Skewness	1.369980	6.279660	2.121998	-11.42634	4.235184	7.523447
Kurtosis	16.85339	51.71127	7.521481	171.0794	31.48809	84.12991
Jarque-Bera	8475.510	107547.3	1634.350	1222850.	37541.02	289360.0
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	0.385661	6553.000	12133.50	-0.655000	7.808786	0.173047
Sum Sq. Dev.	0.148500	627391.2	553959.5	0.029704	0.091707	0.000137
Observations	1020	1020	1020	1020	1020	1020

	TRENDDEV2	VOL2
Mean	-39.82725	0.002582
Median	-1094.800	-0.086397
Maximum	147755.7	7.901363
Minimum	-74609.93	-6.048281
Std. Dev.	17225.22	0.914128
Skewness	0.971590	1.625089
Kurtosis	11.14245	17.94201
Jarque-Bera	2978.209	9937.662
Probability	0.000000	0.000000
Sum	-40623.80	2.633138
Sum Sq. Dev.	3.02E+11	851.5077
Observations	1020	1020

As to some econometric methodological issues, we will make use of Eviews 5 User's Guide by QMS (2004: 585-587) for the explanations. At first dealing with volatility analysis in a standard GARCH(1,1) specification given below, we can consider that,

$$y_t = x_t^{'}\gamma + \varepsilon_t \tag{6}$$

$$\sigma_t^2 = \varpi + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{7}$$

Equation (6) is the mean equation written as a function of exogeneous variables $x_t^{'}s$ with an error term. In equation (7), σ_t^2 gives the one period ahead forecast variance based on past information, and is called as the conditional variance. This conditional variance equation is a function of three terms, i.e. the mean ϖ, the ARCH term ε_{t-1}^2 which gives the news about volatility from the previous period measured as the lag of the squared residual from the mean equation, and the GARCH term σ_{t-1}^2 which is the last period's forecast variance. The (1,1) in GARCH(1,1) refers to the presence of a first order GARCH term and a first order ARCH term. We can consider higher order GARCH models denoted as GARCH*(p,q)* by choosing either *p* or *q* greater than 1. An ordinary ARCH model is a special case of a GARCH specification in which there are no lagged forecast variances in the conditional variance equation. Introducing the conditional variance into the mean equation, we get the ARCH-in-Mean (ARCH-M) model (Engle, Lilien and Robins, 1987: 391-407),

$$y_t = x_t^{'}\gamma + \sigma_t^2 + \varepsilon_t \tag{8}$$

If we also consider that,

$$v_t = \varepsilon_t^2 - \sigma_t^2 \quad (9)$$

substituting for the variances in the variance equation and rearranging terms, we can write our model in terms of the errors,

$$\varepsilon_t^2 = \varpi + (\alpha + \beta)\varepsilon_{t-1}^2 + v_t - \beta v_{t-1} \quad (10)$$

thus, the squared errors follow a heteroskedastic ARMA(1,1) process. The autoregressive root which governs the persistency of volatility shocks is the sum of α and β, and an estimated value close to unity means that shocks die out rather slowly, which is often observed in high frequency financial data.

Following these explanations, in Table 2 below, we try to estimate the effects of foreign exchange interventions on the level and volatility of exchange rate through GARCH(1,1) analysis in equation (6) and equation (7) letting also conditional variance affect the mean equation as expressed in equation (8). For this purpose, we estimate the mean and variance equations such as in equation (11) and equation (12),[12]

$$DLNDOLAR_t = \alpha_1 + \alpha_2\sigma_t^2 + \alpha_3 BUYING_t + \alpha_4 SELLING_t + \alpha_5 DINTEREST_t + \varepsilon_t \quad (11)$$

$$\sigma_t^2 = \beta_1 + \beta_2\varepsilon_{t-1}^2 + \beta_3\sigma_{t-1}^2 + \beta_4 BUYING_t + \beta_5 SELLING_t + \beta_6 DINTEREST_t \quad (12)$$

TABLE 2: GARCH ESTIMATION PROCESS OF THE EXCHANGE RATE VOLATILITY

Dependent Variable: DLNDOLAR
Method: ML-ARCH (Marquardt)
Sample: 26.02.2001 01.04.2005
Included observations: 1033 after adjusting endpoints
Bollerslev-Wooldridge robust standard errors & covariance
Cariance backcast: ON

	Coefficient	*Std.Error*	*z-Statistic*	*Prob.*
GARCH	*-1.094203*	*2.265796*	*-0.482922*	*0.6292*
C	*-0.000763*	*0.000307*	*-2.487646*	*0.0129*
BUYING	*9.24E-06*	*8.56E-06*	*1.079149*	*0.2805*
SELLING	*7.84E-05*	*2.76E-05*	*2.843507*	*0.0045*
DINTEREST	*-0.002155*	*0.008733*	*-0.246785*	*0.8051*
		Variance Equation		
C	*5.68E-06*	*1.76E-06*	*3.222482*	*0.0013*
ARCH(1)	*0.353505*	*0.072648*	*4.865975*	*0.0000*
GARCH(1)	*0.623016*	*0.063500*	*9.811236*	*0.0000*
BUYING	*1.91E-08*	*5.98E-08*	*0.320015*	*0.7490*
SELLING	*1.20E-06*	*5.56E-07*	*2.150713*	*0.0315*
DINTEREST	*0.000495*	*0.000172*	*2.887384*	*0.0039*
AIC	*-6.495061*			

[12] To deal with potential model misspecification, we have calculated robust *t*-ratios using the quasi maximum likelihood method suggested by Bollerslev and Wooldridge (1992: 143-172) so that parameter estimates will be unchanged but the the estimated covariance matrix will be altered.

SC	*-6.442455*		
Q(20)	*24.493*	*Prob.*	*0.222*
Q(36)	*34.031*	*Prob.*	*0.563*
Q^2(20)	*7.9849*	*Prob.*	*0.992*
Q^2(36)	*13.801*	*Prob.*	*0.998*

The main output from ARCH estimation in Table 2 is divided into two sections. The upper part provides the standard output for the mean equation, while the lower part, labeled "Variance Equation" contains the coefficients, standard errors, z-statistics and p-values for the coefficients of the variance equation. The ARCH parameters correspond to α and the GARCH parameters to β in Equation 7 above.

Letting a standard GARCH (1,1) procedure in Table 2 reveal that selling auctions have a significant impact on the level of exchange rate return in a positive way, that is, selling auctions in foreign exchange market seems to increase the exchange rate return rather than decreasing it. If we consider that selling auctions were implemented just after the crisis period of February 2001 carrying on throughout the whole year, the interventions might have been perceived by market participants as a sign of increasing uncertainty in the market leading them to require higher price for exchange rate. We could not estimate a significant impact of buying interventions or interest rate cuts inside the period on the change in exchange rate level. Also no impact of conditional variance on exchange rate return could be appeared.

Considering the variance equation, selling auctions tend to increase the volatility in exchange market. Since the sum of the ARCH and GARCH terms is close to one, the volatility shocks are persistent so that the forecasts of the conditional variance converge to the steady state quite slowly. Buying interventions seem not to affect the volatility of exchange rate return, whilst changes in overnight interest rates such as interest rate cuts affect the volatility in a positive way such that interest rate cuts have been decreasing the volatility of exchange rate return. Also dealing with diagnostics, correlogram-Q statistics for the presence of autocorrelation in the standardized residuals and in the squares of standardized residuals cannot reject the null at conventional levels in the sense that no remaining serial correlation in the mean equation is detected. We should specify that we have estimated the GARCH model by including additional ARCH and GARCH terms in the variance equation, such as GARCH (1,2), GARCH(2,1) and GARCH (2,2) estimation processes, but have found just the same results.

We now try to follow Ardıç and Selçuk (2005), Selçuk (2005: 295-312) and Selçuk and Ardıç (2005) in order to reveal the dynamic relationships between applied interventions and their *ex-post* results, so we aim to appreciate whether our findings estimated so far are consistent with each other giving general conclusions. For this purpose, we apply to some contemporaneous vector autoregression estimation techniques (VARs) such as Granger causality and impulse response analysis.

Let us follow Johnston and Dinardo (1997: 287-301), Greene (2000: 740-747) and QMS (2004: 708-716), and assume first an *AR(p)* process,

$$y_t = m + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \ldots + \alpha_p y_{t-p} + \varepsilon_t \tag{13}$$

We now consider a column vector of k different variables,

$$y_t = [y_{1t}\, y_{2t} \ldots y_{kt}]' \tag{14}$$

and model this in terms of the past values of the vector as a VAR. The VAR*(p)* process would thus be,

$$y_t = m + A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + \varepsilon_t \tag{15}$$

The A_i are *kxk* matrices of coefficients, m is a *kx1* vector of constants and ε_t is a vector of white noice process, with the properties,

$$E(\varepsilon_t) = 0 \text{ for all } t \quad E(\varepsilon_t, \varepsilon_s') = \begin{cases} (\Omega, & s=t) \\ (0, & s \neq t) \end{cases} \tag{16}$$

where the Ω covariance matrix is assumed to be positive definite.[13] Thus ε's are serially uncorrelated but may be contemporaneously correlated. Let us now explain some of the basic features of VARs by considering the simple case where $k=2$ and $p=1$. This would give,

$$y_t = \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} m_1 \\ m_2 \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} = m + Ay_{t-1} + \varepsilon_t \tag{17}$$

Thus, as in all VARs, each variable is expressed as a linear combination of the lagged values of itself and lagged values of all other variables in the system. In such a system of VARs, the behavior of the y's will depend on the properties of the A matrix. For simplicity, we ignore the deterministic time trends and other exogeneous variables in our demonstration.

Sometimes one may wish to test whether a specific variable or group of variables plays any role in the determination of other variables in the VAR. Causality in the sense defined by Granger is inferred when lagged values of a variable y_{2t} have explanatory power in a regression of a variable y_{1t} on lagged values of y_{1t} and $y_{2\,t}$. Let us suppose that a two-variable VAR as in equation (17) is specified as,

$$y_t = \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \tag{18}$$

Here the lagged value of y_2 plays no role in the determination of y_1. Thus, y_2 is said to not Granger cause y_1. The hypothesis that y_2 does not Granger cause y_1 could be tested simply by running the regression of y_1 on the lagged values of y_1 and y_2 and examining whether the coefficient of the latter

[13] When A is *nxn* and symmetric which is the matrice whose transpose A' equals to A, A is positive definite if $\delta' A \delta > 0$ for all *nx1* vectors $\delta \neq 0$.

variable is significantly different from zero. More generally, the y vector might be partitioned into two subvectors: y_1 of order k_1x1 and y_2 of order k_2x1. The hypothesis that the block y_2 does not Granger cause y_1 is tested by estimating the first k_1 equations of the VAR and testing whether the coefficients of the lagged y_2 vectors differ significantly from zero.

Let us carry on following Johnston and Dinardo (1997: 287-301), Greene (2000: 740-747) and QMS (2004: 708-716), and try to examine the construction of short run dynamic interactions amongst the variables used. Consider again a two variable VAR system such as equation (17) but explicitly in this case,

$$y_{1t} = m_1 + a_{11}y_{1,t-1} + a_{12}y_{2,t-1} + \varepsilon_{1t} \tag{19}$$

$$y_{2t} = m_2 + a_{21}y_{1,t-1} + a_{22}y_{2,t-1} + \varepsilon_{2t} \tag{20}$$

A perturbation in ε_{1t} has an immediate and one-for-one effect on y_{1t}, but no effect on y_{2t}. In period $t+1$, that perturbation in y_{1t} affects $y_{1,t+1}$ through the first equation and also affects $y_{2,t+1}$ through the second equation. These effects work through to period $t+2$, and so on. Thus a perturbation in one innovation in the VAR sets up a chain reaction over time in all variables in the VAR. Impulse response functions calculate these chain reactions. The path whereby the variables return to the equilibrium is called the impulse response of the VAR (Greene, 2000: 745).

A shock to the *i-th* variable not only directly affects the *i-th* variable but is also transmitted to all of the other endogenous variables through the dynamic lag structure of the VAR. An impulse response function traces the effect of a one time shock to one of the innovations on current and future values of the endogenous variables. If the innovations ε_t are contemporaneously uncorrelated, interpretation of the impulse response is straightforward. The *i-th* innovation $\varepsilon_{i,t}$ is simply a shock to the *i-th* endogenous variable $y_{i,t}$. Innovations, however, are usually correlated, and may be viewed as having a common component which cannot be associated with a specific variable. In order to interpret the impulses, it is common to apply a transformation to the innovations so that they become uncorrelated. In our paper, we apply to the generalized impulses as described by Pesaran and Shin (1998: 17-29) which construct an orthogonal set of innovations that does not depend on the VAR ordering. The generalized impulse responses from an innovation to the *j-th* variable are derived by applying a variable specific Cholesky factor computed with the *j-th* variable at the top of the Cholesky ordering.

We now try to construct an unrestricted VAR model using daily observations as explained above in order to examine the possible *ex-post* consequences of the foreign exchange interventions of the monetary authority. A preliminary anaysis reveals that the appropriate lag length for our VAR model tends to be the maximum choosen lag, which is not sensitive whether we use the most popular minimized Akaike information criterion (AIC) or the sequential modified likelihood ratio (LR) statistics which starts from the maximum lag and decreases the lag one at a time until first getting a rejection. Since the VAR model lag length tends to be the maximum one as to the choosen maximum

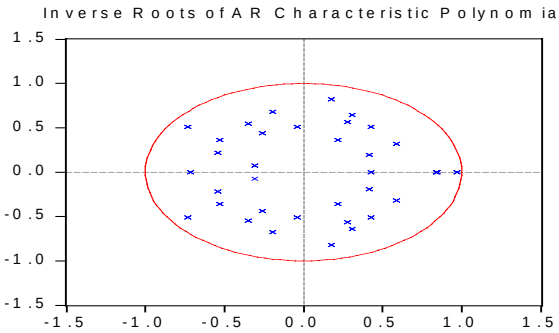
lag order, we will apply to lag order 7 and lag order 14 for our different VAR model considerations so that we aim to control whether the estimated results are sensitive to the lag specification in the choosen VAR model.

The first VAR model we consider consists of the variables DLNDOLAR, SELLING, BUYING, DINTEREST and VOL. Using 7 days horizon in Table 3, Figure 7, and Figure 8 we give the pairwise Granger causality block exogeneity wald test and generalized impulse response estimation results considering 1000 Monte Carlo repetitions of plus/minus two standard deviations. For the pairwise Granger causality tests in which each equation are represented by columns and probs. are in parantheses, we test whether an endogeneous variable can be treated as exogeneous under the null hypothesis. For each equation in the VAR, we consider χ^2 *(Wald)* statistics for the joint significance of each of the other lagged endogeneous variables in that equation. The statistic in the last row *(All)* is the χ^2 statistic for the joint significance of all other lagged endogeneous variables in the equation.

TABLE 3: VAR PAIRWISE GRANGER CAUSALITY/BLOCK EXOGENEITY WALD TEST

Dependent Variable	*DLNDOLAR*	*BUYING*	*SELLING*	*DINTEREST*	*VOL*
DLNDOLAR		*2.619580*	*2.433216*	*30.47749*	*24.38588*
		(0.9178)	*(0.9320)*	*(0.0001)*	*(0.0010)*
BUYING	*13.50970*		*1.688114*	*9.139504*	*4.722947*
	(0.0606)		*(0.9751)*	*(0.2428)*	*(0.6937)*
SELLING	*64.51202*	*1.094934*		*69.83159*	*92.43232*
	(0.0000)	*(0.9931)*		*(0.0000)*	*(0.0000)*
DINTEREST	*45.43129*	*4.761942*	*1.587395*		*52.75629*
	(0.0000)	*(0.6890)*	*(0.9791)*		*(0.0000)*
VOL	*14.30572*	*14.30572*	*18.53709*	*33.00779*	
	(0.0460)	*(0.0460)*	*(0.0098)*	*(0.0000)*	
All	*152.0358*	*17.47707*	*29.29508*	*127.1752*	*177.2429*
	(0.0000)	*(0.9386)*	*(0.3977)*	*(0.0000)*	*(0.0000)*

FIGURE 7: INVERSE ROOTS OF AR CHARACTERISTIC POLYNOMIAL

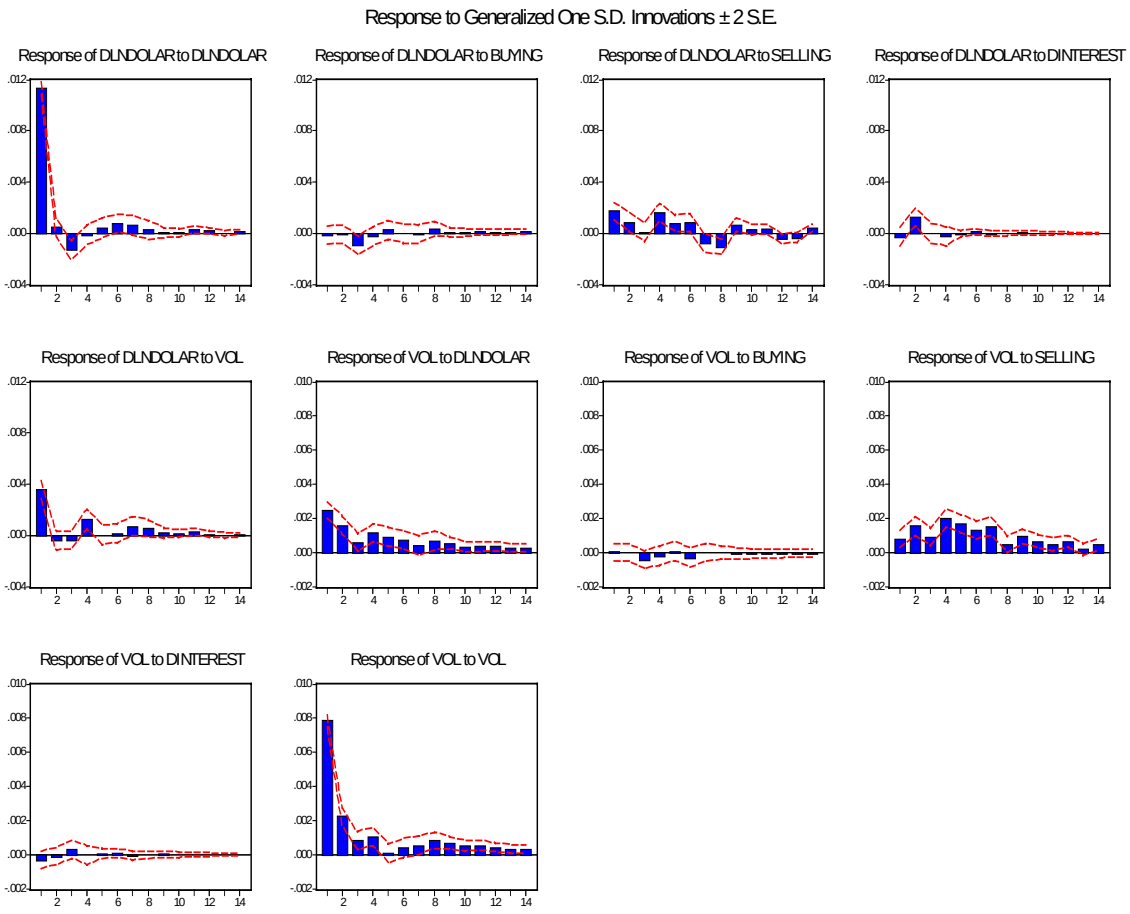


Pairwise Granger causality test results reveal that buying auctions, selling auctions, change in central bank overnight interest rate and the absolute value of exchange rate return as a measure of exchange rate volatility seem to be Granger cause separately and as a whole to changes in exchange rate return. There exists no such factors that Granger cause to buying auctions, whilst only does the exchange rate volatility Granger cause to selling auctions. Change in exchange rate return, selling

auctions and exchange rate volatility Granger cause to change in overnight interest rates, but no effect of buying auctions with respect to change in interest rate has been found. As to the our main interest subject of exchange rate volatility, the daily log-return on exchange rate, the selling auctions and change in interest rate Granger cause to the course of exchange rate volatility, but we have not estimated such an effect on volatility through buying auctions.

As can be seen in Figure 7, we also report the inverse roots of the characteristic AR polynomial such that the estimated VAR would be stable (stationary) if all the roots have modulus less than 1 and lie inside the unit circle. If the VAR is not stable, certain results such as impulse response standard errors are not valid. The estimated results point out that the VAR stability condition check suggests that the model satisfies the stability condition.

FIGURE 8: GENERALIZED IMPULSE RESPONSES – LAG 7



In this respect, if we try to estimate the generalized impulse responses in Figure 8 dealing with exchange rate return and exchange rate volatility in our VAR system, a positive shock to the selling auctions leads to a positive and statistically significant response of log-return of the exchange rate and this effect carries on 6 days, whilst some negative responses of exchange rate return occur later than 7 and 8 days. Thus opposite to a common acceptance that selling auctions of monetary authority to the

foreign exchange market should decrease the return on exchange rate through supply-side effects, our estimation results lead us to refuse this conclusion such that the interventions might have been perceived by market participants as a sign of increasing uncertainty in the market leading them to require higher price for exchange rate supporting the findings estimated through GARCH analysis above.

A positive shock to exchange rate return has also a positive significant effect on exchange rate volatility such as selling auctions. A one standard deviation positive shock to selling auctions increases volatility rather than decreasing it, whilst no statistically significant effect of shocks to buying auctions as well as shocks to change in overnight interest rates is estimated by our system approach. Considering lag specification 14 below in Table 4, Figure 9 and Figure 10 supports the above results with some difference that buying auctions do not Granger cause to log-return of exchange rate and change in overnight interest rate does not Granger cause to exchange rate volatility.

TABLE 4: VAR PAIRWISE GRANGER CAUSALITY/BLOCK EXOGENEITY WALD TEST

Dependent Variable	*DLNDOLAR*	*BUYING*	*SELLING*	*DINTEREST*	*VOL*
DLNDOLAR		*8.333594*	*25.70078*	*68.04969*	*47.29288*
		(0.8712)	*(0.0282)*	*(0.0000)*	*(0.0000)*
BUYING	*16.56155*		*2.062199*	*14.95408*	*10.07507*
	(0.2803)		*(0.9999)*	*(0.3813)*	*(0.7567)*
SELLING	*84.45803*	*3.096862*		*70.28040*	*106.5102*
	(0.0000)	*(0.9989)*		*(0.0000)*	*(0.0000)*
DINTEREST	*29.99355*	*12.44549*	*11.67182*		*12.74256*
	(0.0076)	*(0.5706)*	*(0.6326)*		*(0.5469)*
VOL	*45.36032*	*8.960818*	*37.44055*	*45.33081*	
	(0.0000)	*(0.8336)*	*(0.0006)*	*(0.0000)*	
All	*179.5104*	*31.06952*	*87.47845*	*192.9907*	*201.9330*
	(0.0000)	*(0.9972)*	*(0.0045)*	*(0.0000)*	*(0.0000)*

FIGURE 9: INVERSE ROOTS OF AR CHARACTERISTIC POLYNOMIAL

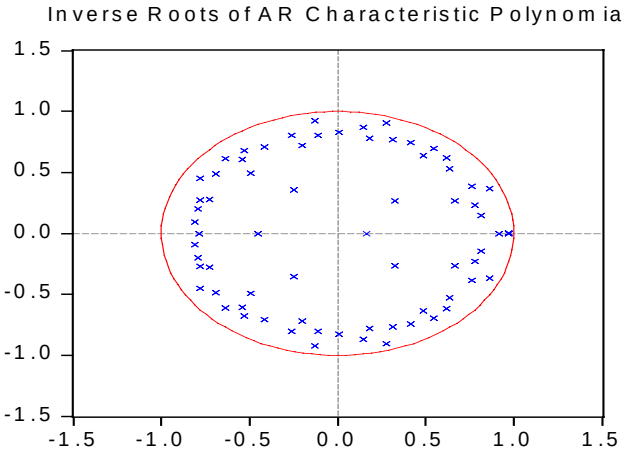
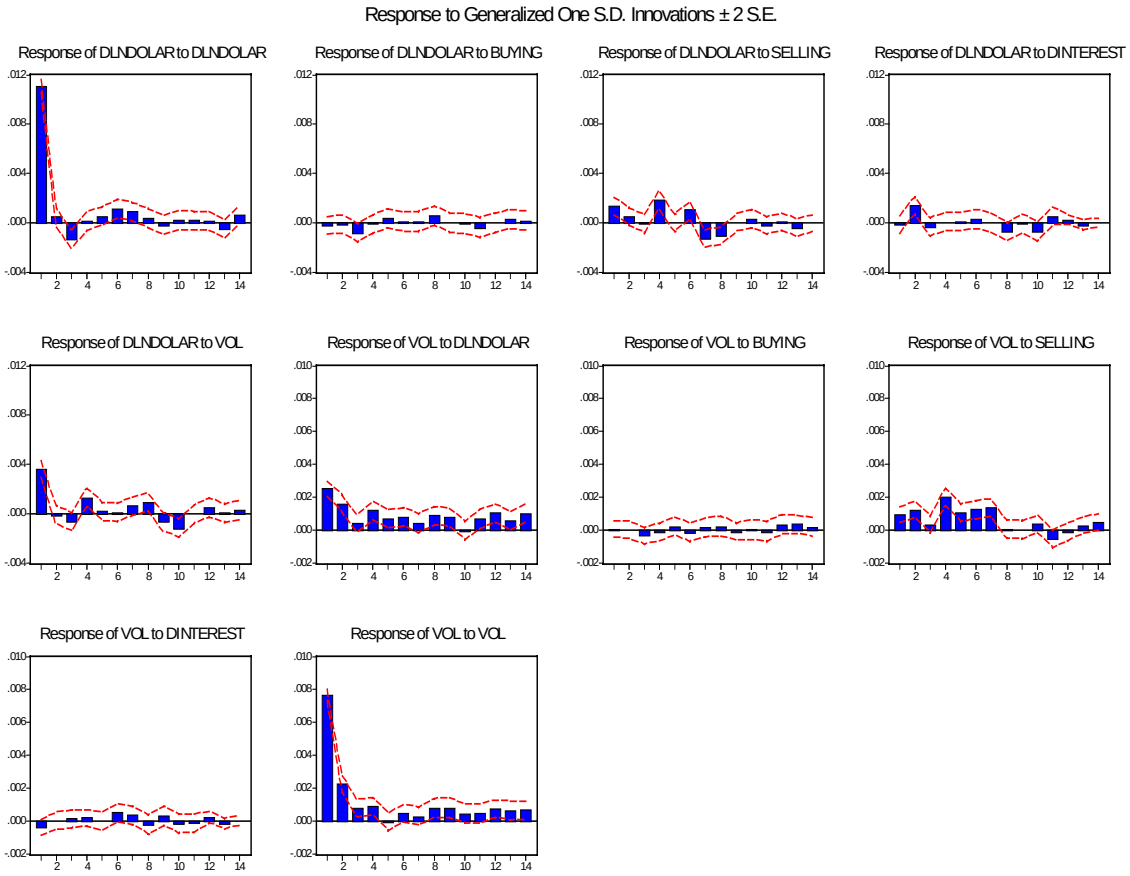


FIGURE 10: GENERALIZED IMPULSE RESPONSES – LAG 14



When taking care of conditional variance of exchange rate estimated through using GARCH methodology (GARCH01) as a measure of volatility with a lag length 7 in Table 5, Figure 11 and Figure 12, we estimate almost the same results through pairwise Granger causality analysis with a VAR model satisfying the stability condition. All the endogeneous factors seem to be Granger cause to exchange rate log return. No explanatory factor has been found dealing with buying auctions, whilst the volatility factor is the main determinant of the selling auctions. Change in overnight interest rate is affected by selling auctions and log return of exchange rate. The estimation results also support the above findings such that log return of exchange rate and selling auctions affect the exchange rate volatility. Also buying auctions have no determining effect on exchange rate volatility. Generalized impulse response analysis reveals that a one standard deviation shock to selling auctions increases both log return of exchange rate and its volatility significantly. Besides, a negative shock to change in overnight interest rate has a significant and immediate positive effect on exchange rate volatility. As can be followed below, using lag length 14 yields the same results

TABLE 5: VAR PAIRWISE GRANGER CAUSALITY/BLOCK EXOGENEITY WALD TEST

Dependent Variable	*DLNDOLAR*	*BUYING*	*SELLING*	*DINTEREST*	*GARCH01*

DLNDOLAR		*3.747718*	*4.415460*	*22.10821*	*139.1395*
		(0.8083)	*(0.7309)*	*(0.0024)*	*(0.0000)*
BUYING	*13.94647*		*1.337573*	*8.934134*	*1.085469*
	(0.0521)		*(0.9874)*	*(0.2574)*	*(0.9933)*
SELLING	*67.12186*	*0.445050*		*73.97637*	*142.9727*
	(0.0000)	*(0.9996)*		*(0.0000)*	*(0.0000)*
DINTEREST	*59.81711*	*4.361800*	*6.290156*		*66.93845*
	(0.0000)	*(0.7373)*	*(0.5063)*		*(0.0000)*
GARCH01	*15.76561*	*0.971986*	*21.57710*	*8.551121*	
	(0.0273)	*(0.9953)*	*(0.0030)*	*(0.2865)*	
All	*153.6959*	*10.10577*	*32.36753*	*100.4673*	*430.5292*
	(0.0000)	*(0.9992)*	*(0.2598)*	*(0.0000)*	*(0.0000)*

FIGURE 11: INVERSE ROOTS OF AR CHARACTERISTIC POLYNOMIAL

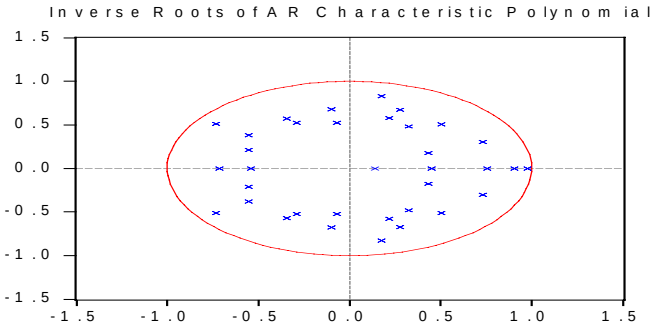


FIGURE 12: GENERALIZED IMPULSE RESPONSES – LAG 7

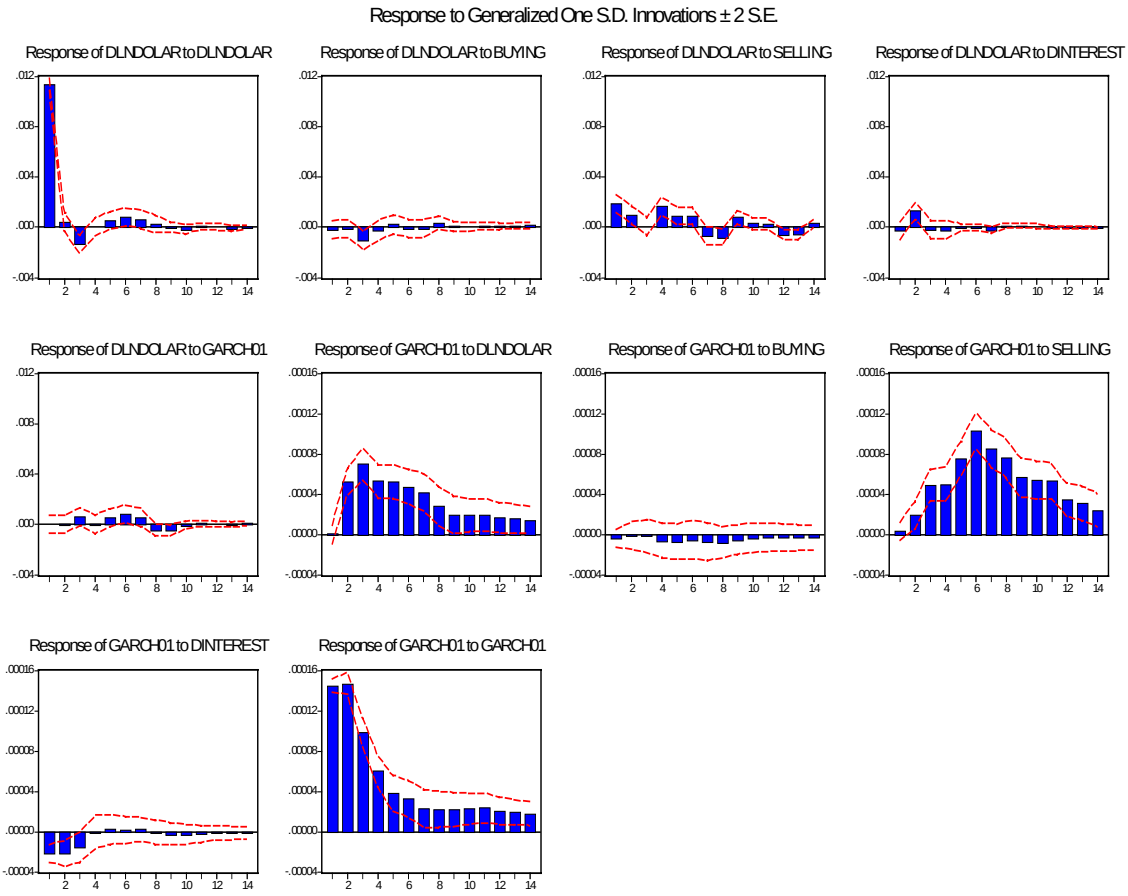


TABLE 6: VAR PAIRWISE GRANGER CAUSALITY/BLOCK EXOGENEITY WALD TEST

Dependent Variable	*DLNDOLAR*	*BUYING*	*SELLING*	*DINTEREST*	*GARCH01*
DLNDOLAR		*11.77236*	*29.78674*	*61.95797*	*190.2212*
		(0.6246)	*(0.0082)*	*(0.0000)*	*(0.0000)*
BUYING	*17.26636*		*1.534865*	*13.99405*	*3.905364*
	(0.2423)		*(0.9999)*	*(0.4502)*	*(0.9960)*
SELLING	*88.08698*	*1.660445*		*70.78547*	*162.7704*
	(0.0000)	*(0.9999)*		*(0.0000)*	*(0.0000)*
DINTEREST	*37.96512*	*11.26576*	*13.55461*		*12.8900*
	(0.0005)	*(0.6650)*	*(0.4834)*		*(0.5352)*
GARCH01	*65.21251*	*2.122748*	*35.33034*	*20.24509*	
	(0.0000)	*(0.9999)*	*(0.0013)*	*(0.1226)*	
All	*202.0436*	*24.07347*	*85.26109*	*164.1760*	*455.7644*
	(0.0000)	*(0.9999)*	*(0.0071)*	*(0.0000)*	*(0.0000)*

FIGURE 13: INVERSE ROOTS OF AR CHARACTERISTIC POLYNOMIAL

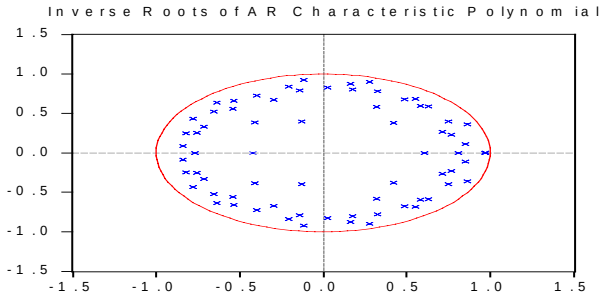
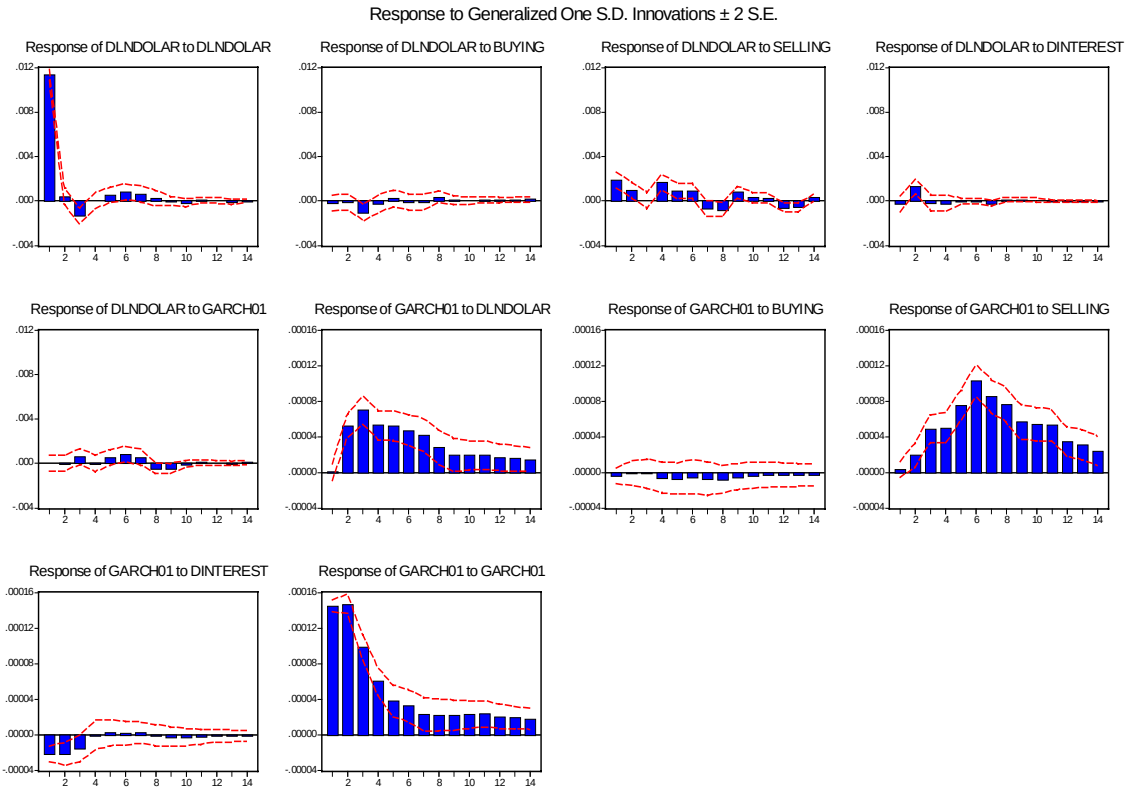


FIGURE 14: GENERALIZED IMPULSE RESPONSES – LAG 14

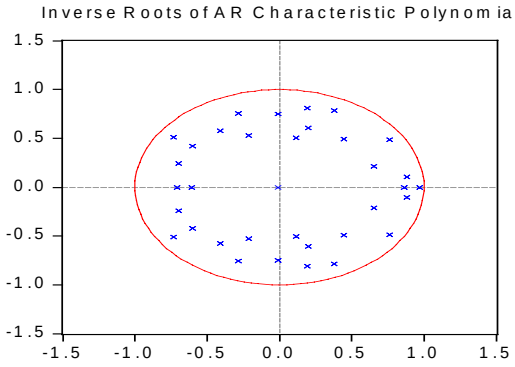


The estimation results so far reveal that our estimations, to the great extent, do not sensitive to the lag length used. Therefore we carry on our analysis by using only lag length 7 to save space. If we replace the variable GARCH01 with TRENDDEV2, we estimate in Table 7, Figure 15 and Figure16 that,

TABLE 7: VAR PAIRWISE GRANGER CAUSALITY/BLOCK EXOGENEITY WALD TEST

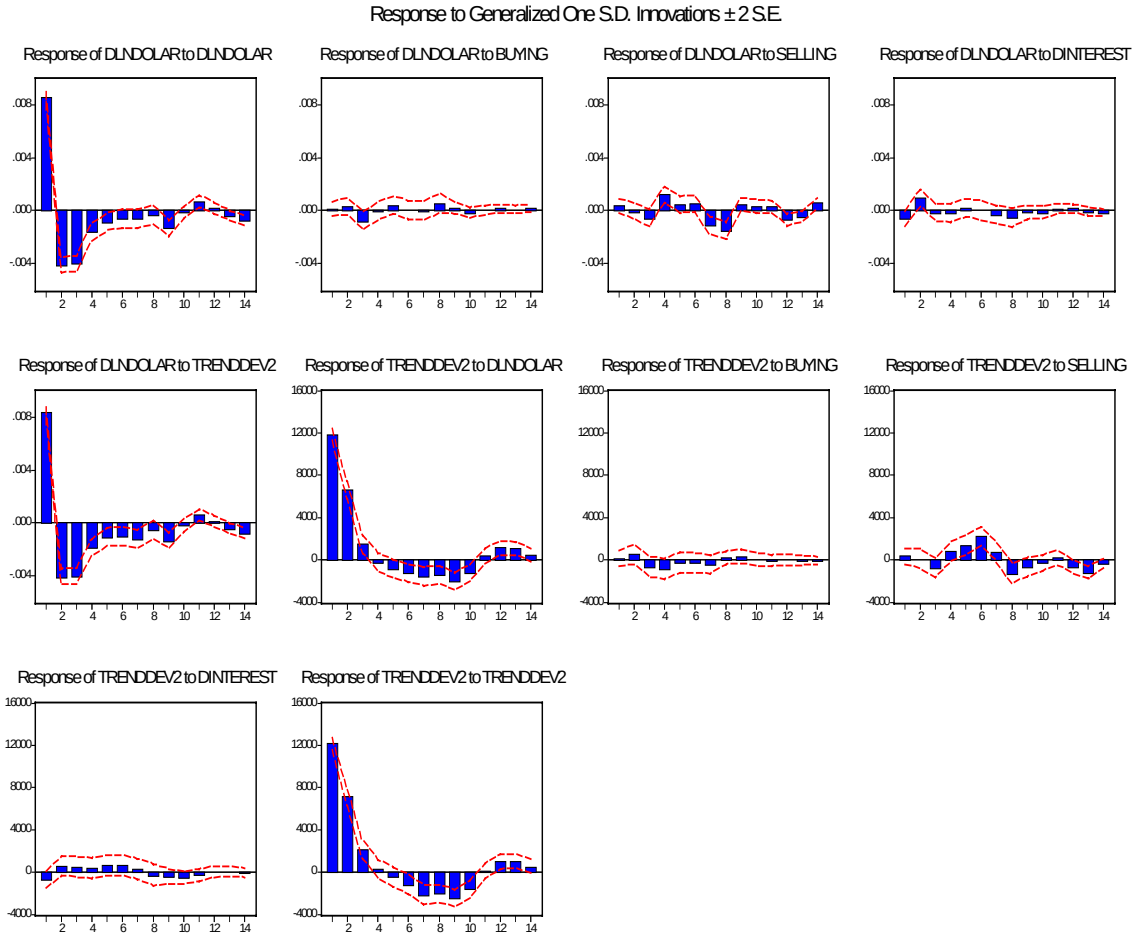
Dependent Variable	*DLNDOLAR*	*BUYING*	*SELLING*	*DINTEREST*	*TRENDDEV2*
DLNDOLAR		*8.854476*	*27.16577*	*14.40138*	*136.9088*
		(0.2633)	*(0.0003)*	*(0.0445)*	*(0.0000)*
BUYING	*8.473136*		*4.207224*	*9.352320*	*8.725117*
	(0.2927)		*(0.7556)*	*(0.2283)*	*(0.2730)*
SELLING	*60.35885*	*0.487994*		*71.71246*	*60.31199*
	(0.0000)	*(0.9995)*		*(0.0000)*	*(0.0000)*
DINTEREST	*9.809485*	*9.338401*	*1.893284*		*6.85990*
	(0.1996)	*(0.2293)*	*(0.9655)*		*(0.4436)*
TRENDDEV2	*747.6878*	*7.919316*	*47.44817*	*6.496983*	
	(0.0000)	*(0.3398)*	*(0.0000)*	*(0.4831)*	
All	*908.6137*	*21.92823*	*59.38276*	*98.58022*	*224.6742*
	(0.0000)	*(0.7846)*	*(0.0005)*	*(0.0000)*	*(0.0000)*

FIGURE 15: INVERSE ROOTS OF AR CHARACTERISTIC POLYNOMIAL



Granger causality analysis points out that selling auctions and the volatility variable TRENDDEV2 seems to be Granger cause to the changes in exchange rate. Verifying the estimation results above, buying auctions has an exogeneous characteristics to our system of variables. Exchange rate return and TRENDDEV2 have a determining effect upon selling auctions, and also selling auctions rather than buying auctions affect how changes the overnight interest rate. Similarly selling auctions is Granger cause to exchange rate volatility and generalized impulse response analysis below in Figure 18 points out that the direction of causality is positive, that is, selling auctions lead the exchange market in a more volatile condition.

FIGURE 16: GENERALIZED IMPULSE RESPONSES – LAG 7



Finally, we use exchange rate pressure index expressed above as a measure of volatility. With VAR lag length 7 in Table 8, Figure 17 and Figure 18, exchange rate volatility and log return of exchange rate are found as Granger cause to selling auctions, but no feedback effects occur towards buying auctions. Change in overnight interest rate is affected by all the endogeneous factors except the buying auctions. Now, buying auctions are found as Granger cause to exchange rate volatility in addition to selling auctions and change in overnight interest rates. Also generalized impulse response analysis results support our earlier findings such that selling auctions rather than buying auctions affect both log return of exchange rate and exchange rate volatility significantly. A one standard deviation shock to selling auctions leads to increasing volatility.

TABLE 8: VAR PAIRWISE GRANGER CAUSALITY/BLOCK EXOGENEITY WALD TEST

Dependent Variable	*DLNDOLAR*	*BUYING*	*SELLING*	*DINTEREST*	*VOL2*
DLNDOLAR		*1.098303*	*27.11284*	*33.74448*	*7.912001*
		(0.9931)	*(0.0003)*	*(0.0000)*	*(0.3404)*
BUYING	*14.28547*		*2.048747*	*8.914921*	*14.16098*
	(0.0463)		*(0.9571)*	*(0.2588)*	*(0.0484)*

SELLING	*68.02196*	*0.434990*		*75.16314*	*70.00650*
	(0.0000)	*(0.9997)*		*(0.0000)*	*(0.0000)*
DINTEREST	*46.84324*	*4.380085*	*3.606373*		*47.70550*
	(0.0000)	*(0.7351)*	*(0.8238)*		*(0.4436)*
VOL2	*8.821967*	*1.134337*	*27.63508*	*33.23323*	
	(0.2657)	*(0.9924)*	*(0.0003)*	*(0.0000)*	
All	*145.8000*	*10.26962*	*38.49012*	*127.4214*	*147.9204*
	(0.0000)	*(0.9991)*	*(0.0895)*	*(0.0000)*	*(0.0000)*

FIGURE 17: INVERSE ROOTS OF AR CHARACTERISTIC POLYNOMIAL

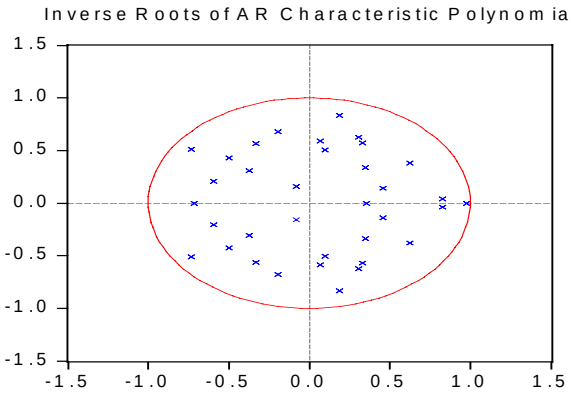
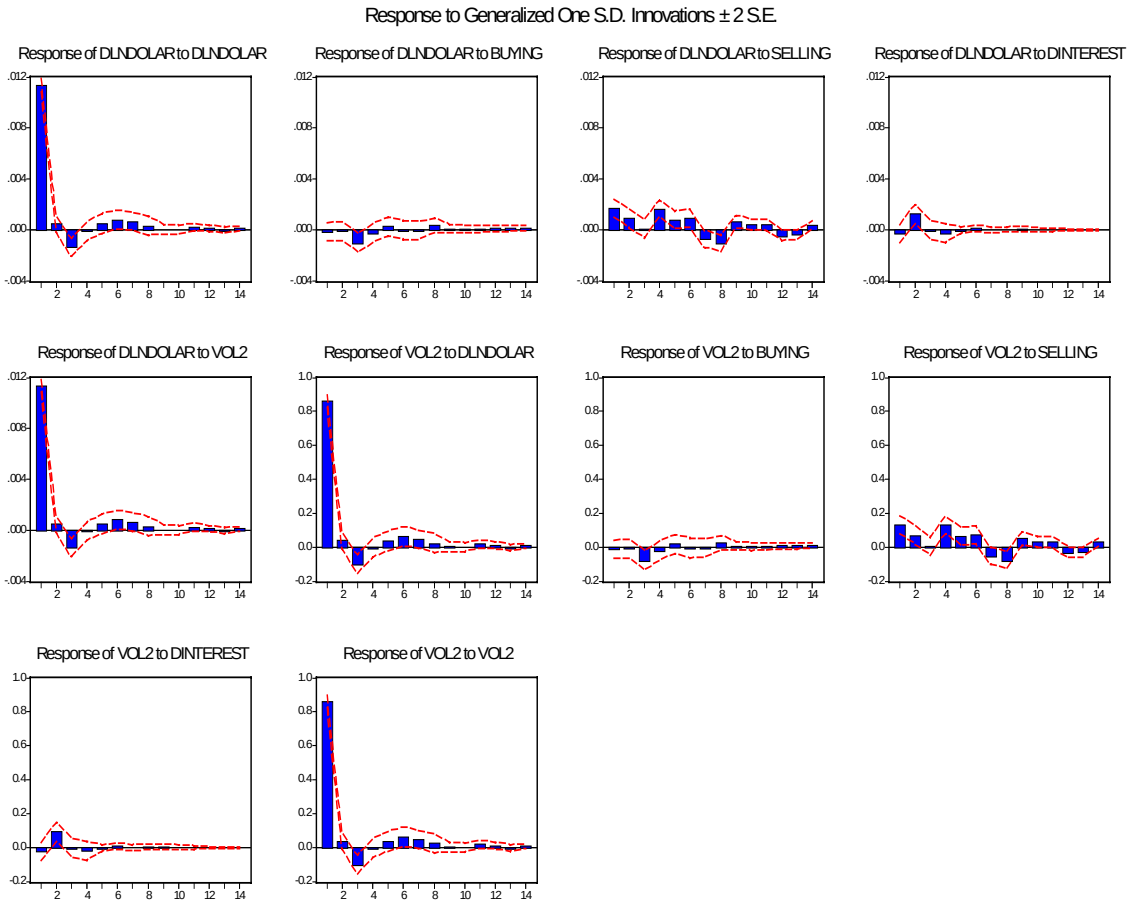


FIGURE 18: GENERALIZED IMPULSE RESPONSES – LAG 7



5. CONCLUDING REMARKS

In our paper, we have tried to investigate what possible factors affect and be affected by foreign exchange operations of the CBRT for the post-crisis period. Having examined briefly both the course of monetary policy stance of the CBRT and the intervention policies for the post-2001 period, and using modern time series econometrics making use of well known generalized autoregressive conditional heteroskedasticity (GARCH) methodology and some unrestricted vector autoregression techniques (VARs) in order to reveal the dynamic relationships between applied interventions and their *ex-post* results, we have indicated the degree of effectiveness of the interventions of monetary authority throughout implicit inflation targeting framework and appreciated whether our findings are consistent with each other giving general conclusions. Based on our estimation results, we have found as a main policy conclusion that the CBRT interventions seem to be under the control of uncertainties in economic environment, rather than decreasing the volatilities in exchange market, and this case in turn leads the interventions being inefficient. Dealing also with the direction of these interventions, sale auctions rather than the buying auctions seem to be effective in conduct of the monetary policy.

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