Sectoral Asymmetries, Currency Mismatch and Sudden Stops

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Abstract: Recent financial crises in developing countries have exhibited sharp falls in capital flows, i.e. sudden stops and accompanying large output drops. Several models have tried to connect these two facts quantitatively. Since sudden stops cannot generate large output drops quantitatively, these models introduce other frictions that have little supporting evidence. In this paper, we present a two-sector model where there is an amplification mechanism generated by two frictions: borrowing constraints; and currency mismatch in non-tradable sector. To support the existence of these distortions we construct a micro data set for Turkey, and show that both non-tradable and tradable sectors of the economy are borrowing constrained with non-tradable sector's investment being more responsive to their internal funds. Furthermore, we document that there is a sizable currency mismatch in the non-tradable sector. Using these distortions, we can generate large output movements as response to sudden stops in our model. When there is a reversal in the current account, the domestic currency depreciates which decreases the net worth of the firms. Accompanied with a currency mismatch, this creates balance-sheet problems for firms where their net worth shrinks and their debt burden swells up. Given that they are constrained by their net worth, firms' investment and output will plummet as a consequence. Most of the adjustment takes place in non-tradable sector leading to sectoral asymmetries.

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1. Introduction

Recent experience of crises in developing countries has several features that are difficult to model quantitatively. Two main features of these crises are the sudden reversal in current account or abrupt decrease in capital flows to the country; called a sudden stop; and an accompanying large output drop. There have been different quantitative models trying to model this behavior. But as noted by Chari, Kehoe and McGrattan (2005), sudden stops alone are not enough to generate large output drops quantitatively. The models that get the output decrease introduce some other frictions that have little direct evidence. Understanding the mechanism through which capital movements translate into output movements poses an important question to comprehend the economic conditions of the developing countries.

In this paper, we will first present micro data evidence from Turkey for capital market imperfections. By analyzing the investment behavior of sectors in the economy we will show that there are financial constraints in the both non-tradable and tradable sectors. We will also document that a large currency mismatch exists in non-tradable sector. Using these features we will construct a multi-sector quantitative model where we can replicate the observed output movements as in data. We calibrate our macro model to three developing countries (Turkey, Mexico and Korea) with the experience of sudden stops, and show that our model can account for the large outputs decreases as a response to sudden stops as well as the sectoral asymmetries and relative price movements. Given a sudden stop, there will be a depreciation of domestic currency. The depreciation will create balance-sheet problems for the firms with currency mismatch. These balance-sheet problems in return will reduce the net worth of the firms. With their investment

constrained by their net worth, firms will cut investment and output creating decreases in output. In this process, currency mismatch will work as the amplification mechanism.

In the first part of the paper we will present some micro evidence from Turkey for the capital market frictions that we will use in the quantitative model. Using industry and firm level data we document that in both non-tradable and tradable sectors of the economy, investment behaviors are significantly correlated with internal funds. This result leads us to conclude that both sectors are financially constrained. Furthermore, the investment behavior is asymmetric in the sense that non-tradable sector's responsiveness is significantly higher than tradable sector's. These financial constraints imply that movements in the bank credit will propagate through financial accelerator as described by Bernanke, Gertler and Gilchrist (2000). In this propagation process we will have an amplification mechanism created by currency mismatch. Using micro data, we present that there is a sizable currency mismatch in non-tradable sector. The currency mismatch will be the crucial amplification mechanism of the quantitative model.

In the second part of the paper, using the micro data-established frictions of borrowing constraints and currency mismatch, we construct a multi-sector quantitative model. We first regenerate the result that in one-sector model with just borrowing constraints, sudden stops are not enough to create the output drops comparable to data in size, as it is the case in Chari, Kehoe and McGrattan (2005). Then, we write a two-sector model with borrowing constraints and currency mismatch. We calibrate this model to the three cases of sudden stop crises: Turkey in 1994 and 2001, Mexico in 1994 and Korea in 1997. When subjected to the observed movements of capital flows in all three countries, our model will be able to produce the large output movements as in the data. Moreover, we

will replicate the asymmetric behavior of output and relative prices also. During a sudden stop, there will be a huge amount of capital inflow from the country. This will lead to a depreciation of the domestic currency. Accompanied with a currency mismatch, depreciation will create balance-sheet problems for firms where their net worth shrinks and their borrowing swells up. Given that firms are constrained by their net worth, firms' investment and output will plummet as a consequence.

The rest of the paper is organized as follows: Second part gives the stylized facts about the boom-bust cycles and sudden stops in three developing countries, depicts the sectoral asymmetries and links it to credit markets. Third part use micro data to establish the link between output and credit markets more rigorously and estimates the investment behavior of different sectors o the economy for Turkey. The fourth part presents the model and calibration. Last part concludes.

2. Stylized Facts

In this part we analyze the stylized facts that motivate this study. We give the capital flows and output movements for three developing countries: Turkey, Korea and Mexico for the period 1990-2005. We then present the sectoral asymmetries for output over the typical cycle for Turkey. We also try to connect this with credit markets. Then we give a detailed account of the currency mismatch in the economy. Our analysis can be considered as a detailed country study of the more general works of Tornell and Westermann (2002a, 200b and 2003).

Upper panel of the Figure 1 depicts the capital flows as a percentage of the output in Turkey for the period 1990-2005. There were two main sharp reversals in capital flows:

first in 1994 and second in 2001. Both of them correspond to the crises in Turkey. In the 1994 reversal, capital outflows were 8% of output, and in 2001 outflows were around 14%. This phenomenon of sharp and large reversal in capital flows is called sudden stops Calvo (1998). During these sharp reversals, percentage deviations of the output from HP trend are –4.76% and –9.03%, respectively. So large output drops accompany these sudden stops. Figure 2 graphs the capital flows and percentage output deviation for Mexico and Korea also. Mexico experienced a sudden stop in 1994: reversal in the capital flows was 7.5% and percentage deviation in output was –6.3%. Similarly Korea experienced a sudden stop in 1997: reversal in capital flows was 7.7% and percentage output deviation was –7.6%.

One common procedure in literature to decompose the output is to check the expenditures like consumption and investment. It is a well-known fact that investment is usually more volatile than consumption. Another possible way to decompose the output is to divide it between sectors. Then one can see the differential response of sectors to the boom-bust cycles and crises.

In their papers, Tornell and Westermann show that there are sectoral asymmetries in output for middle-income developing countries. They separate output into two parts called tradable and non-tradable sectors depending on the criteria of price volatility and tradability. Then they document that over a typical cycle non-tradable sector is more volatile. Moreover they show that there is a significant correlation between the ratio of non-tradable to tradable output and the ratio of credit to output, after accounting other important variables like financial liberalization and trade liberalization. This suggests that credit/financial markets can be an important determinant of the sectoral asymmetries.

Furthermore, they document that especially before the crises; there is a high level of currency mismatch in these countries.

2.1. Sectoral Asymmetries

We decompose the output into Non-Tradable (NT) and Tradable (T) sectors. We group construction industry, wholesale and retail trade, services of hotels and restaurants, and transportation and communication as the Non-Tradable (NT) sector. Industry sector is classified as Tradable (T) sector. Export to output ratio justifies this classification also. We do not include agriculture, because agriculture has a decreasing share over the whole period. Including agriculture with T sector only gives a trend to NT over T ratio. We analyze the 1990-2004 period for Turkey because we have detailed industry level data for this period. Trivial exercises extend this period back to 1970.

In Figure 3, first panel gives the ratio of NT to T output. As can be seen from the graph NT/T ratio closely follows the overall boom-bust cycles in the economy in Figure 1. During the boom NT grows faster than T-sector so that the ratio increases and during the bust NT decreases more than T-sector so that the ratio decreases. So the response of NT-sector over the cycle is more responsive.

As in Tornell and Westermann, we will try to connect this asymmetry to credit markets. In Figure 3, in second panel we graph the credit to private sector as a percentage of GDP over the same period. We see a close relation between NT/T and Credit/GDP ratios. We can suggest that NT sector is more responsive to the credit and so any movement in credit can induce movements in NT/T ratio. We will use micro data set to get this channel in detail in part three. Panel 3 in Figure 3 gives the real exchange rate for the period. As we see during a boom, an appreciation of the domestic currency accompanies the increase in NT/T ratio. During the sudden stops of 1994 and 2001, we see sharp depreciation

accompanied with a decrease in NT/T ratio. The close correlation between NT/T ratio, credit over output ratio and real exchange rate hints about the importance of capital markets for this asymmetrical response.

We use annual data from 1970 to 2004 to quantify the relationship between Credit/GDP and NT/T ratio after controlling other factors. Table 1 provides the regression results. Since both Credit/GDP and NT/T ratios are not rejected to be unit root we use the first differences in the regressions. Credit to GDP ratio affects NT to T-sector output ratio with one lag. As also documented by Tornell and Westermann, we see that trade liberalization affects NT/T ratio negatively in the sense that it helps more to T sector. Financial liberalization affects NT/T ratio positively. We expect that with financial opening credit in the economy will increase and this will benefit NT-sectors more that are more financially constrained than T-sectors. Gunay and Kilinc (2006) give a more detailed analysis of the regressions.

Figure 4 provides the impulse responses of NT/T to an innovation in credit to GDP ratio. Left one is the annual impulse response from 1970-2004 and right one is the quarterly impulse response from 1987Q1-2004Q4.Both shows that effect of credit on NT/T becomes significant during the second year. This is in accordance with Table 1.

Tornell and Westermann analyses the sectoral asymmetries and the link with credit markets for middle income developing countries. They also conclude that during a boom, credit grows fast, non-tradable grows faster than tradable and currency appreciates. There is a strong correlation between credit and NT/T ratio, and trade liberalization affects this ratio negatively whereas financial liberalization affects it positively. So our results here confirm to the general characteristic of developing countries.

2.2 Currency Mismatch

There will be a currency mismatch for an agent when the net foreign asset position of the agent is negative. For a bank this can mean that they have more foreign currency denominated borrowing than their foreign currency denominated assets. This is usually an easy variable to measure. But this masks an implicit form of currency mismatch. A bank can borrow in foreign currency and lend this in foreign currency also, therefore

creating no negative net foreign asset position. Then one should check the currency mismatch by the borrowing firms, too. To capture this point, we will construct some indexes of currency mismatch from our industry level survey. This survey is detailed data set of industries in Turkish economy from 1990 to 2003. It approximately covers six to eight percent of total employment and total output in the economy. Average number of firms in each year is around ten thousand. We examine the data in two-digit industry classification. This provides us with eight non-tradable industries and fifteen tradable industries continuously for the period 1998-2003.

Table 2 gives a detailed analysis of foreign currency positions of the industries. First part gives some statistics about the short term and total foreign currency debt with respect to both total debt and total sales. Both short term and total FX debt of both industries are significant portions of total debt. An initial comparison of short FX debt as a portion of sales to foreign sales to sales ratio reveals that non-tradable sectors are never able to cover their short FX debt position with their exports. Including long term FX debt just exaggerates the problem.

In the second part of Table 2, we construct several indexes of currency mismatch. Index 1 gives the ratio of short FX debt to exports. Non-tradable sectors have a very high open position that decreases later. Index 2 shows the same for total FX debt. Rest of the indexes compares relative size of these variables.

From this evidence, we see that non-tradable sector has a big currency mismatch in the balance sheets. This poses a big risk for the economy, because given the high volatility of exchange rate and possibility of crises; this makes the balance sheet of industries very open to the unfavorable adjustments. Tornell and Westermann (2003) also check the

currency mismatch for other countries including Korea and Mexico before their corresponding crises. Korea has the same currency mismatch as Turkey and Mexico has a higher currency mismatch. From this we will conclude that our mechanism here will also apply to Mexico and Korea, and other developing countries with currency mismatch and financing constraints.

3. Micro Evidence

In the previous part, we presented the evidence from macro data that non-tradable output is more volatile over the cycle. In other words, during a boom non-tradable output is growing faster than tradable output and during a bust non-tradable output is growing slower or decreasing faster than tradable output. Moreover, we establish a significant correlation between non-tradable to tradable output ratio and credit to GDP ratio. This sectoral asymmetry and link with financial markets are also established for other middle-income developing countries in Tornell and Westermann (2003).

To establish the link between sectoral asymmetry and financial markets more rigorously, we follow the large body of literature in finance that studies the relationship between financial markets and investment. We use the results from this literature that when there are capital market imperfections, internal funds will be an important determinant of investment. And internal funds will be an irrelevant for investment when the capital markets are perfect.[1]

The first detailed paper to analyze this relationship in an empirical way rigorously is Fazzari, Hubbard and Peterson (1988). They conduct the cash-flow regression analysis in

[1] In Modigliani and Miller (1958) frictionless capital market world, structure of the financial market is irrelevant for the investment. In the case of Myers and Majluf (1984) information problems and Jensen and Meckling (1976) incentive problems, liquidity of firms will be an important determinant of investment.

detail and conclude that more constrained firms exhibit higher sensitivity of investment to internal funds. There are other studies for different data sets and different countries that reach a similar conclusion. But Kaplan and Zingales (1997) criticize this conclusion and say that there is not necessarily a monotonic relationship between higher sensitivity and being more constrained. There are other studies supporting both conclusions.[2] Hubbard (1998) gives a detailed survey of the literature.

Following Hubbard (1998) we assume that a firm wants to maximize stream of profits from investment after adjustment costs of investment. For a firm maximizing the profit stream, Tobin's marginal q will be the main determinant of investment. Here marginal q will control the investment opportunities for a firm.

And to test whether internal funds of the firms matters for the investment decision we can augment the investment equation as follows:

$$\left(\frac{I}{K}\right)_{it} = a_i + \lambda_t + bQ_{it} + c\left(\frac{CF}{K}\right)_{it} + \varepsilon_{it} \qquad (1)$$

where CF is the cash flow of the firm, Q is the Tobin's q, I is investment and K is the beginning of period capital. In a perfect capital markets world, firm's liquidity would not enter as an important determinant of the investment since internal funds and external funds would be perfectly substitutes. But with information problems or incentive problems, there will be wedges between external finance and internal finance, making external finance more costly. In such a framework, firm's investment will be positively related to internal finance available.

3.1 Data and Micro Results

First we will use data surveys from 1992-2003 for different firms for different sectors. This survey has coverage of employment close to eight percent of total employment in the whole economy so it is a very broad sample and more representative of the whole economy than other studies. In the literature people only check firms in the stock market, which are already very big firms with access to financial markets. Then results from these would not be representative for the economy. We will also check the stock firms and see that it is not at all representative of the larger picture, both from survey and macro movements. Kesriyeli, Ozmen and Yigit (2005) also empirically show that Turkish firms have currency mismatch and are vulnerable to balance sheet effects.

3.1.1 Survey Results

Table 3 gives the summary statistics for the non-tradable and tradable sectors for the period of 1992-2003. We present cash flow, investment, sales and change in sales as a ratio of capital of last period. Cash flow as a fraction of capital is higher for tradable sector for the whole period. For the crises years of 1994 and 2001, we have negative investment and change in sales as expected. We can also see that during a boom sales growth of non-tradable sector is usually higher than tradable sector and during the crises years the decrease in sales is higher in non-tradable. This is in line with our macro data result that non-tradable sector is more volatile over the cycle.

Since most of the firms are not traded in the stock market, we need to find another variable instead of Q in regression to control for the investment opportunities. As suggested by the literature we will use change in sales as the proxy for investment

opportunities of the firm. Then Table 4 gives the results for OLS regressions and Fixed-Effects regressions. Gunay and Kilinc (2006) estimate the model in more detail with Random-effects regressions and GMM instrumental variables approaches also. They also test the difference of the coefficient for the cash-flow variable for tradable and non-tradable sectors. The coefficient of cash flow variable is significantly higher for non-tradable sectors.

As we see from Table 4, cash flow seems to be an important determinant of investment for firms in both sectors. They are always significant at one percentage level. This tells that neither tradable nor non-tradable sectors have access to perfect capital markets and are constrained by their internal funds. Then as we compare the sectors we see that non-tradable sector are always more constrained than tradable sectors. We conduct a test and get that the coefficient for non-tradable is always significantly bigger than tradable coefficient.

The non-tradable sectors have coefficients of cash flow from 0.48 to 0.52 for fixed effects. This magnitude for tradable sectors is from 0.33 to 0.34. We can also decompose sector in tradable part into small and large firms. Gunay and Kilinc (2006) find that for large firms we do not have any effect from cash flow and change in sales is more relevant. So we can conclude that for big firms, financial constraints do not play an important role. On the contrary, for small firms cash flow is significant and a large number. This is an important distinction because most of the literature uses firms from stock market that are very large. Then those results would not be representative of the economy.

From these results we can see that in the economy non-tradable sectors are always financially constrained and responsiveness is higher. Tradable sectors are classified as constrained with respect to fixed investment but tradable firms are less constrained than non-tradable firms.

Gelos and Werner (2002) consider the investment behavior for manufacturing firms in Mexico for the period 1084-1994. They find that firms are financially constrained. These kind of empirical papers are mostly about the stock market firms or manufacturing firms. Then it is difficult to infer about the aggregate investment. As stated by Hubbard (1998), estimating investment equations for other sectors of the economy would provide helpful for aggregate investment dynamics. In the Turkish case, we can estimate the investment equations for non-tradable and tradable sectors of the economy, and get micro evidence for the aggregate investment and output dynamics. In our estimation we have a higher sensitivity of non-tradable sector. This implies that non-tradable firms will be more responsive to external finance or bank credit. So when there is a lending boom, non-tradable firms will be investing and producing more, and when credit decreases non-tradable sector will decrease investment and output more than tradable sector. Coupled with the currency mismatch, the behavior of non-tradable firms will be amplified. Then this framework presents a micro evidence for the macro correlations between NT/T ratio and Credit/GDP ratio, and establishes the link between credit markets and output dynamics.

3.1.2 Stock Market Results

We also conduct cash-flow regression analysis on stock market firms. Our period covers 1993 to 1997. We exclude financial and utility firms. Again we categorize our firms into non-tradable and tradable sectors. Table 5 reports the results.

Since these are the firms in the stock market we also use Market-to-Book value as another control variable for investment opportunities. Because we do not have enough detail to estimate better value for Tobin's q ourselves, using replacement costs or some other methodology, we take reported market-to-book values. These turn out be insignificant in the regressions. We also estimate change in sales as another control variable and see that it performs better than approximate q.

After using both approximate q and change in sales, we can see that cash flow is not a significant variable for investment. Only in non-tradable sectors case we have very small negative effect.

Since the firms in the stock market are large with respect to other firms in the economy and they are expected to have better access to financial markets, we don't reject the hypothesis that there are perfect capital markets for these firms. Comparing these to the previous section for a larger and more representative data set for economy, we conclude that using stock market firms can tell us whether they are constrained or not, but it does not help with studying the big macro picture.

From these micro results, we can conclude that market imperfections are important for the economy and there is an asymmetry across sectors that non-tradable sectors are more constrained than tradable sector.

4. Macroeconomic Model

We pointed to the macro relationship between non-tradable to tradable ratio and private credit to GDP ratio. We saw that there was a close relationship between NT/T ratio and Credit/GDP ratio. We concluded from this that credit market is an important part of the boom-bust cycles in the economy and this effect is asymmetric across sectors. To support these findings we checked two separate micro data sets. For stock market firms, we get that they are not financially constrained and have access to financial markets almost perfectly. But we noticed that this data set is not representative of the economy, since these firms are very large with respect to average firms and have better access to credit markets. To see more representative results, we checked a larger data set for different sectors. From this data set, we concluded that non-tradable sectors are financially more constrained than tradable sectors.

Given the fact that non-tradable sectors are more constrained than tradable firms, we can generate the boom-bust cycles we see in the data. During a credit boom, firms which are more responsive to the credit (non-tradable) will increase their investment and correspondingly their output more than other firms (tradable). So NT/T ratio will increase over the boom. And during a credit bust or decrease, non-tradable firms will decrease investment and output more than other firms, and we will see NT/T ratio decreasing.

After characterizing the micro evidence firmly, we use this as the micro foundation of a macro model. One can write a small open economy model with two sectors of non-tradable and tradable sectors. Putting capital market imperfections in the spirit of Tornell and Westermann (2002), we can get borrowing constraints for non-tradable firms. Then we can calibrate this model to match data on developing countries.

4.1. Literature Review

Recent crises experience of developing countries had two noted characteristics. There was a big and quick decrease in capital flows to country, called sudden stop, and an accompanying large decrease in output. There have been different models in international economics to model these features quantitatively. But as noted by Chari, Kehoe and McGrattan (2005), sudden stops alone are not quantitative enough to generate observed decreases in output. Also, Kehoe and Ruhl (2005) shows that a multi-sector model with borrowing constraints only would not be successful in generating large output drops as a response to sudden stops. They complement the model with frictions in the form of cost of moving inputs across sectors, and calibrate it to Mexico, but this model still cannot reproduce the observed declines in output.

The models that generate large output drops from sudden stops use other frictions that lead to this result. In Christiano, Gust and Roldos (2005) there is a two-sector economy in which firms need to borrow to pay for foreign intermediate inputs. This borrowing is subject to collateral constraint and shocks to this are equivalent to shocks to technology. In Numeyer and Perri (2005), there is a one good economy in which firms need to borrow in advance to pay for a fraction of the wage bill. And these funds do not earn interest. In Mendoza (2005) firms need to borrow to pay for foreign intermediate inputs and these funds do not earn interest also. But as noted by Chari, Kehoe and McGrattan (2005), “the key frictions that generate output drops in existing literature on sudden stops are subtle ones for which there is little evidence.”

In this part, we will first write a one-sector economy and show that sudden stops alone cannot generate large output drops as observed in the data. Then we will make use of our

micro data results: both non-tradable and tradable sectors are borrowing constrained in an asymmetrical way and there is a big currency mismatch in non-tradable sector. We will write a model with these features and show that both sudden stops as shocks to current account and shocks to interest rate will create the key observations: asymmetrical response of NT/T over the cycle, depreciation and large output drop.

4.2. One Sector Model

We write a perfect foresight model with one sector. A social planner maximizes the utility subject to a budget and borrowing constraints:

$$\max_{\{c_t;B_{t+1};K_{t+1}\}} \sum_{t=0}^{\infty} \beta^t U(c_t) \tag{2}$$

subject to budget constraint

$$c_t + [K_{t+1} - (1-\delta)K_t] + [1 + r_t + \varepsilon(e^{B_t - B_s} - 1)]B_t = K_t^{\alpha} + B_{t+1} \tag{3}$$

and a borrowing constraint of the form :

$$B_{t+1} \leq hK_{t+1} \tag{4}$$

There is no labor in the economy; the capital is the only input. In equation (3) economy produces output with capital and borrows from outside. We put the constraint that agents can borrow up to fraction "h" of their capital stock in (4). *B* represents the foreign borrowing. Then they pay their old debt, they invest and consume. We put the adjustment term $\varepsilon(e^{B_t - B_s} - 1)$ into the interest rate function to make the model stationary. When

borrowing exceeds the stationary level, world interest will increase. Solving this simple model will give following first order conditions:

$$U_c(c_t) = \lambda_t \tag{5}$$

$$\lambda_t - \varphi_t = \beta\lambda_{t+1}[1 + r_t + \varepsilon(e^{B_{t+1}-B_s} - 1)] \tag{6}$$

$$\lambda_t - \varphi_t h = \beta\lambda_{t+1}[\alpha K_{t+1}^{\alpha-1} + (1-\delta)] \tag{7}$$

Compared to a model without borrowing constraints, we have the multiplier of borrowing constraint φ_t in the equations (6) and (7). Equation (7) tells that if we increase capital stock by one unit, we will have the marginal productivity benefit plus the extra benefit of $\varphi_t h$. This extra term represents the benefit of relaxing the borrowing constraint by increasing capital stock. In this model we will assume $\beta < 1/(1+r)$ so that agents always want to borrow up to the limit of available credit.

Then with a log utility and parameter values as in Table 6, we solve the model. We both use a shooting algorithm and a linearization scheme and get identical results.

Figure 5 represent the response of economy to a decrease of capital flow around ten percent. This is represented as a decrease in credit over output from forty to thirty percent. As we see the response of output is very small around one percent. Whether we give a shock to *h* or to the world interest rate r, we will get very small changes in output. Then we calibrate this model to Turkish economy from 1990 to 2003. We take the credit to output ratio as given and fit to it an AR (1) process. Then we put the residuals as shocks to a representative economy. Figure 6 shows the calibration result. We take the credit over output from data as given. As we see in the data model cannot generate

observed output movements as in the data. It is successful in creating the current account dynamics, but as noted by Chari, Kehoe and McGrattan (2005), sudden stop alone is not enough to create large output movements. In this framework, a sudden stop leads to depreciation and this will lead to an increase in next exports. This is similar to expansionary of effects of devaluations.

4.3. Two Sector Model

After showing that in a one-sector model, sudden stops alone are not enough to generate the observed output movements; we write a two-sector model. We will have non-tradable and tradable sectors. Both sectors will be borrowing constrained and non-tradable sector will have currency mismatch. Sectors will have sector-specific capital and no labor. Tradable sector will use non-tradable inputs. Both sectors will consume both tradable and non-tradable goods.

Tradable Sector:

Representative tradable agent maximizes utility subject to budget and borrowing constraints:

$$\max_{\{c'_{N,t};c'_{T,t};B_{t+1};K_{T,t+1}\}} \sum_{t=0}^{\infty} \beta^t U(c'_{N,t};c'_{T,t}) \tag{8}$$

subject to budget constraint:

$$c'_{T,t} + p_{N,t}c'_{N,t} + p_{N,t}d_{N,t} + [K_{T,t+1} - (1-\delta)K_{T,t}] + [1 + r_t + \varepsilon(e^{B_t - B_s} - 1)]B_t = K_{T,t}^{\alpha} d_{N,t}^{\theta} + B_{t+1} \tag{9}$$

and borrowing constraint :

$$[1 + r_t + \varepsilon(e^{B_{t+1} - B_s} - 1)]B_{t+1} \leq n(1-\delta)K_{T,t+1} \tag{10}$$

where p is the relative price, d is the non-tradable input to tradable production like services and B is the borrowing. Tradable agent both consumes tradable and non-tradable goods. Production only uses tradable capital and non-tradable input. We again put sensitive interest rate into the model to satisfy stationary. In the borrowing constraint, whatever agent needs to pay next quarter cannot be bigger than some fraction of the depreciated capital agent has, as written in equation (10). Then first order conditions of the agent will be:

FOC:

$$c'_{T,t}: \quad U_{c'_{T,t}}(c'_{N,t};c'_{T,t}) = \lambda_t \tag{11}$$

$$c'_{N,t}: \quad U_{c'_{N,t}}(c'_{N,t};c'_{T,t}) = p_{N,t}\lambda_t \tag{12}$$

$$(11)/(12): \frac{U_{c'_{N,t}}(c'_{N,t};c'_{T,t})}{U_{c'_{T,t}}(c'_{N,t};c'_{T,t})} = p_{N,t} \tag{13}$$

$$B_{t+1}: \quad \lambda_t - \varphi_t[1+r_t+\varepsilon(e^{B_{t+1}-B_s}-1)] = \beta\lambda_{t+1}[1+r_{t+1}+\varepsilon(e^{B_{t+1}-B_s}-1)] \tag{14}$$

$$K_{T,t+1}: \quad \lambda_t - \varphi_t n(1-\delta) = \beta\lambda_{t+1}[\alpha K_{T,t+1}^{\alpha-1} d_{N,t+1}^{\theta} + (1-\delta)] \tag{15}$$

$$d_{N,t}: \quad p_{N,t} = \theta K_{T,t}^{\alpha} d_{N,t}^{\theta-1} \tag{16}$$

As we see in equation (15), increasing the level of capital will make the borrowing constraint slacker, and will give the agent extra benefit $\varphi_t n(1-\delta)$. In equation (14), an increase in debt will increase the cost by interest rate and the extra term $\varphi_t[1+r_t+\varepsilon(e^{B_{t+1}-B_s}-1)]$. This extra term is the cost of making borrowing constraint more binding.

Non-Tradable Sector:

Representative non-tradable agent maximizes utility subject to budget and borrowing constraints:

$$\max_{\{c''_{N,t};c''_{T,t};A_{t+1};K_{N,t+1}\}} \sum_{t=0}^{\infty} \gamma^t U(c''_{N,t};c''_{T,t}) \tag{17}$$

subject to budget constraint:

$$c''_{T,t} + p_{N,t}c''_{N,t} + p_{N,t}[K_{N,t+1} - (1-\delta)K_{N,t}] + [1 + r_t + \varepsilon(e^{A_t - A_S} - 1)]A_t = p_{N,t}K^{\eta}_{N,t} + A_{t+1} \tag{18}$$

and borrowing constraint:

$$[1 + r_t + \varepsilon(e^{A_{t+1} - A_S} - 1)]A_{t+1} \leq mp_{N,t+1}(1-\delta)K_{N,t+1} \tag{19}$$

The non-tradable agents also consume tradable and non-tradable goods. They produce and sell and borrow to finance new borrowing, consumption and investment. The term *A* is the foreign borrowing by non-tradable sector. Since the non-tradable agent makes production in non-tradable units and borrows in tradable units, this borrowing represents currency mismatch. The term "m" is the fraction of after-depreciation capital that agent can borrow up to. But there is an important difference than tradable sector. In equation (19) on the left hand side we have borrowing in terms of tradable good or foreign currency and on the right hand side we have the collateral in terms domestic currency. The price p in front of the capital stock is the difference from equation (10). So whenever p goes down (a depreciation) collateral value will decrease and will make the borrowing tighter. This will enter as an amplification mechanism into the model.

The first order conditions will be as follows:

$$c''_{T,t}: \quad U_{c''_{T,t}}(c''_{N,t}; c''_{T,t}) = \lambda'_t \tag{20}$$

$$c''_{N,t}: \quad U_{c''_{N,t}}(c''_{N,t}; c''_{T,t}) = p_{N,t}\lambda'_t \tag{21}$$

$$(20)/(21): \frac{U_{c''_{N,t}}(c''_{N,t}; c''_{T,t})}{U_{c''_{T,t}}(c''_{N,t}; c''_{T,t})} = p_{N,t} \tag{22}$$

$$A_{t+1}: \quad \lambda'_t - \mu_t[1 + r_t + \varepsilon(e^{A_{t+1}-A_s} - 1)] = \beta\lambda'_{t+1}[1 + r_{t+1} + \varepsilon(e^{A_{t+1}-A_s} - 1)] \tag{23}$$

$$K_{N,t+1}: \quad p_{N,t}\lambda'_t - \mu_t m p_{N,t+1}(1-\delta) = \beta\lambda'_{t+1} p_{N,t+1}[\eta K_{N,t+1}^{\eta-1} + (1-\delta)] \tag{24}$$

As we see from equation (24), when we increase the capital stock we will have the extra benefit of relaxing the borrowing constraint. This is the same as tradable version. But we have another mechanism to relax the borrowing constraint. If domestic currency appreciates, then p goes up and this will relax the borrowing constraint also. And when there is depreciation, p will decrease and also decrease the value of collateral making constraint more binding. This will be the crucial part of the model. By assuming that non-tradable sector has currency mismatch and so by having borrowing or liabilities in foreign currency and assets or collateral in domestic currency, we create balance sheet effects.

During a sudden stop, there will be depreciation of the domestic currency. Other models without currency mismatch get this depreciation also. But after this step, in our model this depreciation will decrease the collateral value and make the borrowing constraint more binding. This will decrease borrowing further which will depreciate the currency

more. Then this currency mismatch generates an amplification mechanism by the balance sheet effects.

We will also have the market clearing conditions for both non-tradable and tradable goods. We also note that any three of two market clearing equations with two budget constraints will imply the fourth one, so in simulations and calibration we will only use three of them.

(T) : (25)

$$c'_{T,t} + c''_{T,t} + [K_{T,t+1} - (1-\delta)K_{T,t}] + [1 + r_t + \varepsilon(e^{B_t - B_s} - 1)]B_t + [1 + r_t + \varepsilon(e^{A_t - A_s} - 1)]A_t = K_{T,t}^{\alpha} d_{N,t}^{\theta} + A_{t+1} + B_{t+1}$$

(NT): (26)

$$c'_{N,t} + c''_{N,t} + [K_{N,t+1} - (1-\delta)K_{N,t}] + d_{N,t} = K_{N,t}^{\eta}$$

Then, seven first order conditions, two borrowing constraints and any three of two budget constraints and two market clearing conditions will give us a system of twelve equations in twelve unknowns of $c'_{T,t}; c''_{T,t}; c'_{N,t}; c''_{N,t}; K_{T,t+1}; K_{N,t+1}; d_{N,t}; A_{t+1}; B_{t+1}; p_{N,t}; \mu_t; \varphi_t$.

Simulation and Calibration

We use same set of parameters as in the previous example with log utility functions. Additional parameter of *n* and *m* (collateral multipliers in equations 10 and 19) are equated to 0.28 to match total credit to output ratio of fifty percent. For utility we will have separable log utility function. First we give shock to these multipliers to generate sudden stops of around five to ten percent of output. This shock can be seen in the figures as a decrease in total credit over output. Figure 7 represent the result of a shock to non-

tradable borrowing of around five percent of output. As we see following the sudden stop (decrease in credit over GDP or increase in trade balance over GDP), there is depreciation around fifteen percent, so non-tradable goods become cheaper. Tradable sector buys more of cheap non-tradable output and increase production, while non-tradable production decreases. During the shock, multiplier on borrowing constraint becomes higher showing that shadow value of external finance is increasing.

We also use interest rate shocks as a more aggregate shock for the economy. Figure 8 shows the impulse responses to an interest rate shock of fifteen percentage points initially, decreasing later. This matches a sudden stop of five percent also. We get very similar results as above with bigger magnitudes. Domestic currency depreciates around twenty percent and decrease in non-tradable sector is bigger. In both cases decrease in total output is around five to eight percent. So we can get large decrease in output with this framework as opposed to Chari, Kehoe and McGrattan (2005).

We also calibrate this model to Turkish, Korean and Mexican economies from 1990-2003. We give the credit over GDP as an exogenous process to the model.[3] We estimate the credit over output in data. We fit an AR (1) to it and feed this into the model to match the exact capital flows over output data by arranging the exogenous shocks to m (borrowing constraint coefficient for non-tradable sector). Since we do not know for each country how he composition of the capital flows change across sectors, we will put the exogenous process on m to match the capital flows. For each country we match the particular capital flow data and then check what happens to the output. Figure 9 illustrates the calibrated data and real data for Turkey. When we have two-sector

[3] Changes in credit are equivalent to capital flows in this model because there is no domestic borrowing. For big negative changes this would be sudden stop like in year 1994 and 2001.

economy with borrowing constraints and currency mismatch, we get the magnitudes of change in calibrated output comparable to data. Figure 10 gives the calibration of Korean and Mexican cases. We can generate output drops in the model comparable to data in size. With these micro evidence supported setup, we can generate large output changes as a response to sudden stops.

5. Conclusion

Using macro and micro evidence, we establish several facts about a typical boom-bust cycle. We show that a usual cycle mask sectoral asymmetries. Over the cycle non-tradable sector is more responsive and there is a significant correlation with financial markets. To establish these facts more rigorously, we use a micro data set and show that both non-tradable and tradable sectors are borrowing constrained. Moreover, non-tradable sector's investment responsiveness is significantly higher than tradable's. Also we show that there is a large currency mismatch in tradable sector.

Using these facts we write a two-sector small open economy model with both sectors being borrowing constrained and non-tradable sector having currency mismatch. We demonstrate that the shocks to current account in the form of sudden stops can create large output dynamics as observed in the data. When there is a reversal in current account, domestic currency depreciates which decreases the net worth of the firms. Accompanied with a currency mismatch, this will create balance-sheet problems for firms where their net worth shrinks and their borrowing swells up. Given that they are constrained by their net worth, firms' investment and output will plummet as a consequence.

As an extension to model one can try to improve ob several fronts. One can put interest rate shocks calibrated from data and try to see whether they are effective in creating the observed movements in output. Another extension would be to get the decomposition of capital flows across sectors and try to match flows by sectors exactly. One can also try to replicate the results of the cash flow regression by the macro model. These are our current research.

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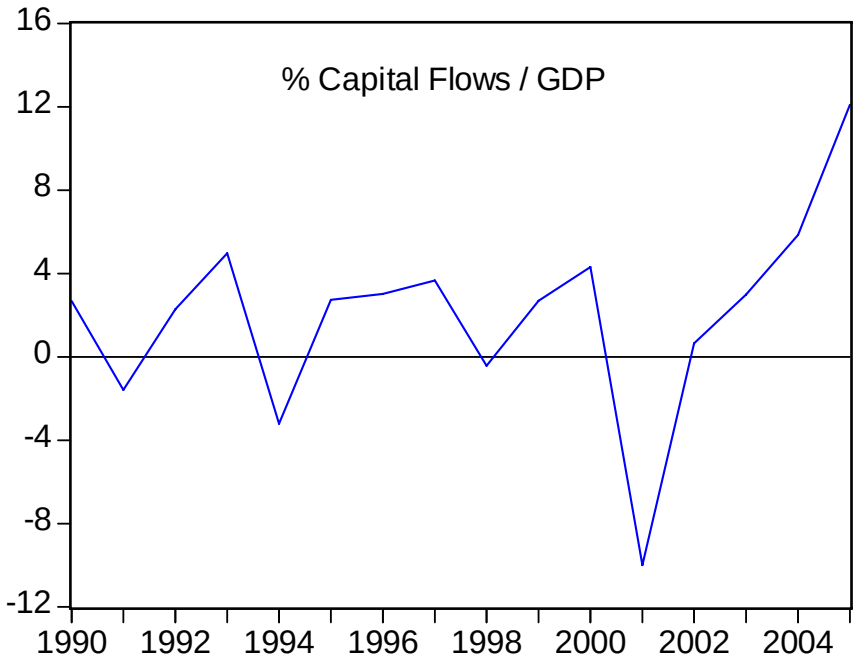
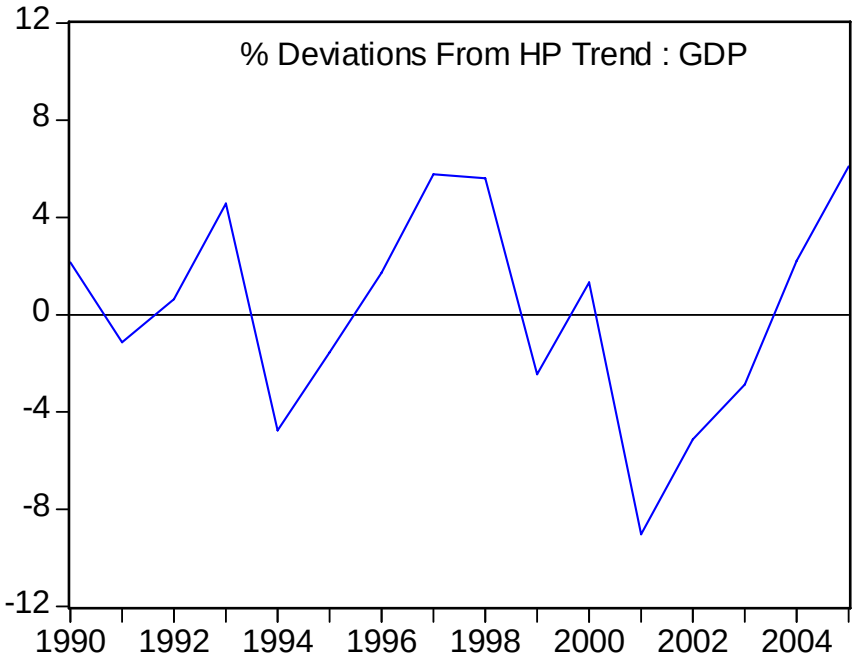
Figure 1 : Turkey





Source : IFS - IMF

Figure 2a : Mexico

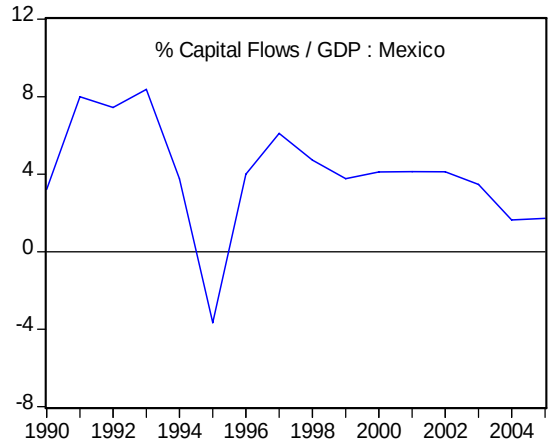
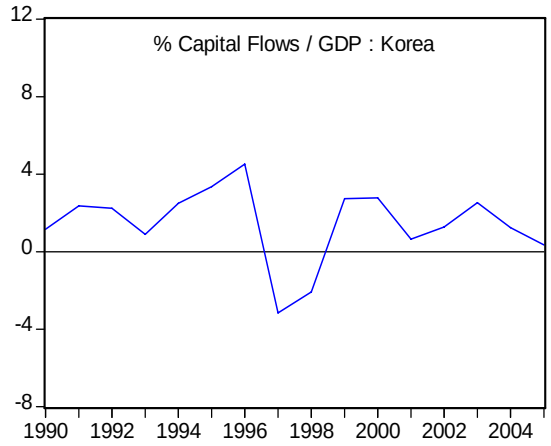
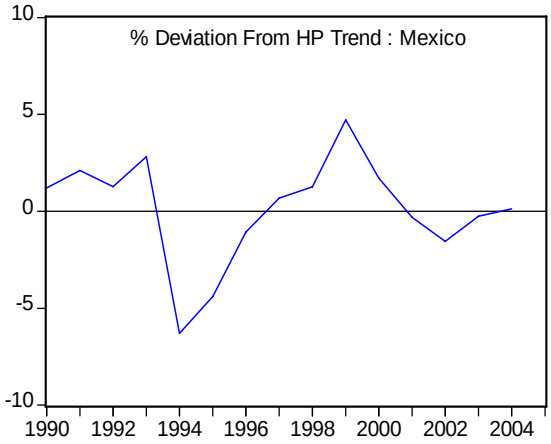
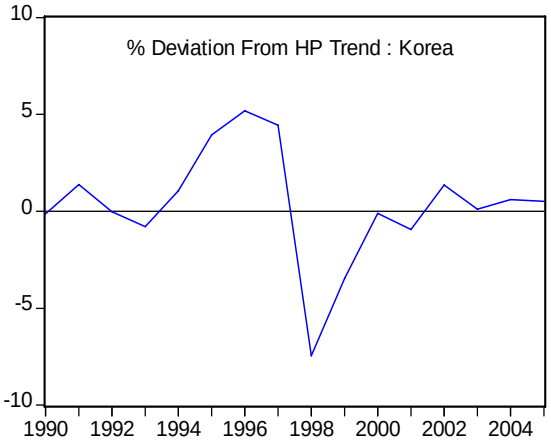


Figure 2b : Korea

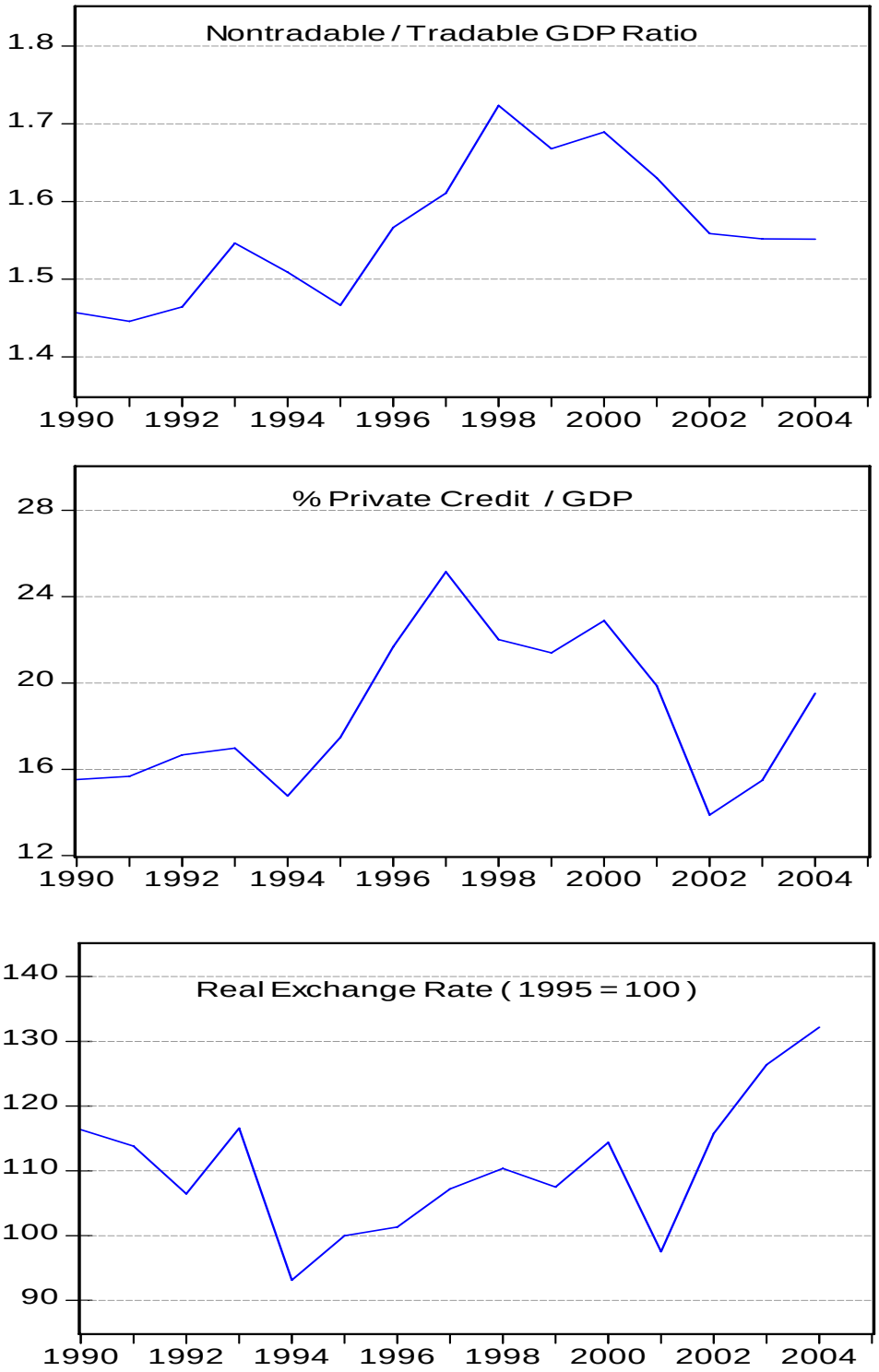






Source : IFS - IMF

Figure 3 : Turkey



Source : Central Bank of Turkey

Table 1: Table for annual data regressions.

Data: 1970-2004

Dependent variable: D(N/T)

	A	B
D(Cr/GDP)	-0.0010	-0.0016
	(0.0071)	(0.0068)
D(Cr/GDP(-1))	0.0146*	0.0127*
	(0.0074)	(0.0072)
TL(-1)		-0.1023**
		(0.0490)
FL		0.0907*
		(0.0479)
Intercept	0.0031	0.0024
	(0.0167)	(0.0256)
Adjusted R^2	0.0564	0.1324

* 10%, ** 5%, *** 1% Significance levels.

Standard deviations are in parenthesis.

D refers to a differenced variable. (-1) refers to one lag. N/T is non-tradable to tradable ratio.Cr/GDP is private sector to GDP ratio. TL (-1) is the trade liberalization dummy with one-year lag, which is the period 1985-2004. FL is the financial liberalization dummy, which is the period 1990-2004.

Figure 4: Impulse Responses of NT/T ratio to Credit/GDP: Annual (Left), Quarter(Right)

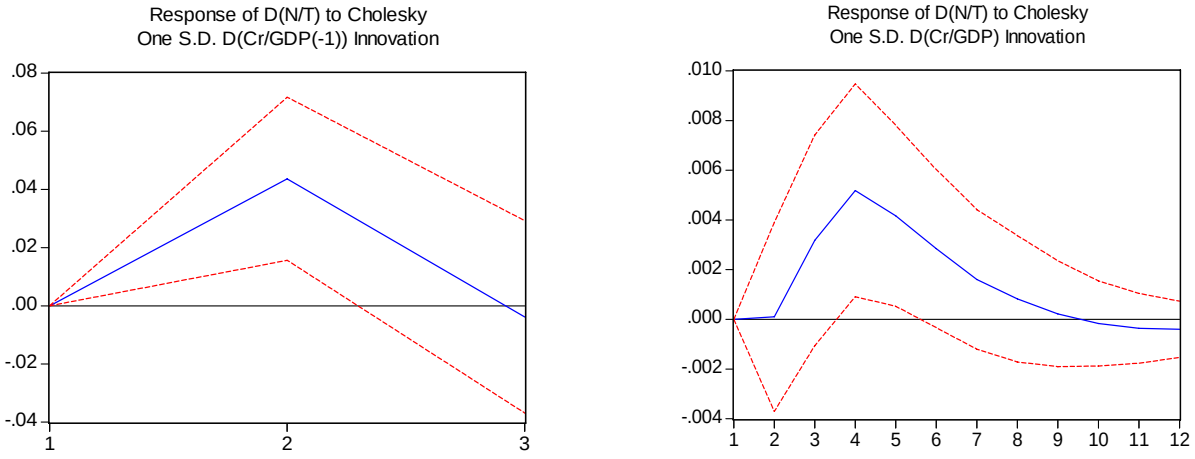


Table 2: Foreign Currency Positions of Industries

	Short FX Debt / Total Debt		Total FX Debt / Total Debt		Foreign Sales / Gross Sales		Short FX Debt / Gross Sales		Total FX Debt / Gross Sales	
	T	**NT**	**T**	**NT**	**T**	**NT**	**T**	**NT**	**T**	**NT**
1998	0.56	0.53	0.72	0.63	0.22	0.11	0.27	0.93	0.34	1.06
1999	0.59	0.49	0.73	0.63	0.23	0.09	0.19	0.49	0.23	0.63
2000	0.49	0.44	0.74	0.70	0.20	0.09	0.13	0.25	0.19	0.39
2001	0.52	0.43	0.77	0.73	0.29	0.13	0.13	0.31	0.20	0.49
2002	0.55	0.38	0.79	0.69	0.29	0.13	0.12	0.17	0.17	0.30
2003	0.47	0.34	0.73	0.60	0.28	0.13	0.09	0.17	0.15	0.30

	Index 1		Index 2		Index 3		Index 4		Index 5	
	T	**NT**	**T**	**NT**	**T**	**NT**	**T**	**NT**	**T**	**NT**
1998	1.34	19.62	1.72	21.17	5.92	44.77	4.16	14.86	6.02	15.91
1999	1.04	9.88	1.31	12.45	5.87	23.41	4.67	9.04	5.79	11.19
2000	0.68	9.93	1.11	14.51	5.10	20.14	3.41	14.06	6.04	21.03
2001	0.48	6.54	0.79	9.35	3.64	22.32	2.82	10.21	4.30	14.28
2002	0.45	2.42	0.66	4.24	3.48	7.98	2.74	4.76	3.89	8.39
2003	0.35	1.80	0.59	3.48	3.31	7.33	2.36	3.64	3.63	6.69

All data are industriy averages for the corresponding year.

Index 1 = Short FX Debt / Exports

Index 2 = Total FX Debt / Exports

Index 3 = (Short FX Debt / Total FX Debt) / (Exports/Gross Sales)

Index 4 = (Short FX Debt / Total Debt) / (Exports/Gross Sales)

Index 5 = (Total FX Debt / Total Debt) / (Exports/Gross Sales)

Table 3
Summary Statistics; Mean and Standard Deviation for Tradable and Non-tradable Sectors

	$\frac{CF_{t-1}}{K_{t-1}}$		$\frac{I_{t-1}}{K_{t-1}}$		$\frac{S_{t-1}}{K_{t-1}}$		$\frac{CS_{t-1}}{K_{t-1}}$		Sales Growth	
Year	**T**	**NT**	**T**	**NT**	**T**	**NT**	**T**	**NT**	**T**	**NT**
1991	-	-	0.02 (0.04)	0.05 (0.03)	5.45 (0.82)	11.78 (10.12)	0.53 (0.22)	0.60 (0.55)	8.29 (2.78)	-1.82 (8.19)
1992	1.35 (0.08)	1.03 (0.42)	0.03 (0.02)	0.08 (0.05)	5.93 (0.81)	13.44 (11.41)	0.53 (0.30)	1.54 (1.07)	13.49 (3.76)	39.67 (22.34)
1993	1.27 (0.10)	1.03 (0.49)	-0.07 (0.04)	-0.06 (0.04)	5.78 (0.81)	15.09 (13.52)	0.02 (0.15)	1.90 (2.10)	-0.07 (2.45)	-5.08 (11.83)
1994	1.25 (0.10)	0.82 (0.23)	0.27 (0.15)	-0.04 (0.05)	6.21 (0.89)	10.47 (6.26)	0.15 (0.54)	-0.72 (0.44)	2.99 (6.88)	-4.66 (7.76)
1995	1.24 (0.09)	0.74 (0.19)	0.06 (0.06)	0.03 (0.08)	5.49 (0.72)	8.21 (3.83)	0.23 (0.34)	-0.80 (1.09)	9.97 (6.79)	14.60 (18.62)
1996	1.12 (0.09)	0.98 (0.22)	0.06 (0.04)	0.04 (0.13)	5.09 (0.54)	8.55 (4.73)	-0.15 (0.18)	-0.09 (0.59)	-0.97 (3.44)	-5.52 (9.86)
1997	1.22 (0.12)	1.16 (0.22)	0.17 (0.04)	0.54 (0.16)	5.82 (0.61)	10.84 (5.94)	0.99 (0.20)	2.30 (1.22)	20.27 (3.35)	28.96 (9.29)
1998	1.22 (0.09)	1.18 (0.27)	0.30 (0.04)	0.32 (0.15)	6.27 (0.65)	10.82 (6.29)	1.18 (0.33)	3.12 (2.23)	22.57 (5.17)	28.46 (6.17)
1999	0.76 (0.07)	0.90 (0.17)	0.01 (0.03)	0.19 (0.12)	4.71 (0.46)	7.74 (3.18)	-0.16 (0.11)	0.76 (0.60)	-2.87 (1.71)	16.12 (10.56)
2000	0.86 (0.07)	1.14 (0.20)	0.00 (0.02)	0.40 (0.19)	5.29 (0.62)	8.90 (4.19)	0.52 (0.23)	2.14 (1.53)	10.44 (4.17)	39.75 (18.17)
2001	0.61 (0.05)	0.53 (0.10)	-0.07 (0.02)	0.02 (0.09)	4.89 (0.61)	5.91 (3.01)	-0.36 (0.19)	-0.73 (0.27)	-7.88 (3.77)	-11.98 (3.09)
2002	0.85 (0.07)	0.69 (0.08)	-0.03 (0.03)	-0.07 (0.08)	5.07 (0.64)	5.25 (1.86)	-0.23 (0.13)	0.10 (0.53)	-3.91 (2.19)	39.52 (25.14)
2003	0.81 (0.06)	0.78 (0.15)	0.03 (0.07)	0.03 (0.04)	5.68 (0.82)	6.81 (3.68)	0.34 (0.20)	0.17 (0.88)	4.59 (3.02)	-16.56 (13.12)

1) Standard deviations for the means are given in parenthesis.
2) CF/K, I/K, S/K, and CS/K are the ratios of Cash Flow, Investment, Sales, and Changes in Sales at the end of time t to Capital Stack at the end of time t-1, respectively. Sales Growth is calculated in %.

Multiple Panel Data Cash Flow Regression explaining Investment for Survey firms in the 1992-2003 period in Turkey.

$$\left(\frac{I_{i,t}}{K_{i,t-1}}\right)=\beta_{0,i}+\beta_{0,t}+\beta_{CF/K,i}\left(\frac{CF_{i,t}}{K_{i,t-1}}\right)+\beta_{CS/K,i}\left(\frac{CS_{i.t}}{K_{i.t-1}}\right)+\beta_{(CS/K)(-1),i}\left(\frac{CS_{i,t-1}}{K_{i,t-2}}\right)+\varepsilon_{i,t}$$

Table 4: Cash Flow Regression

Dependent variable**: Investment/Capital Stock (I/K)**

	Non-tradable Sector								Tradable Sector			
	Unbalanced				Balanced				Balanced			
	OLS		Fixed Effects		OLS		Fixed Effects		OLS		Fixed Effects	
	1	2	1	2	1	2	1	2	1	2	1	2
CF/K	0.134***	0.148***	0.480***	0521***	0.202***	0.232**	0.514***	0.490***	0.082***	0.078***	0.331***	0.340***
	(0.050)	(0.055)	(0.121)	(0.132)	(0.069)	(0.090)	(0.149)	(0.171)	(0.029)	(0.029)	(0.066)	(0.067)
CS/K	0.023**	0.019*	0.005	0.004	0.017	0.013	-0.003	-0.001	0.081***	0.085***	0.024	0.018
	(0.011)	(0.011)	(0.014)	(0.015)	(0.014)	(0.016)	(0.019)	(0.021)	(0.011)	(0.012)	(0.017)	(0.019)
(CS/K)(-1)		0.011		0.016		0.006		0.012		0.010		-0.012
		(0.010)		(0.013)		(0.013)		(0.017)		(0.011)		(0.017)
Intercept	-0.027	-0.033	-0.300***	-0.334***	-0.043	-0.048	-0.284**	-0.251*	-0.063**	-0.062***	-0.284***	-0.288***
	(0.041)	(0.042)	(0.111)	(0.119)	(0.0.57)	(0.068)	(0.134)	(0.147)	(0.032)	(0.031)	(0.068)	(0.069)
Adj. R^2	0.154	0.152	0.342	0.338	0.173	0.184	0.304	0.331	0.340	0.330	0.366	0.364
# of Obs	82	78	82	78	64	56	64	56	180	180	180	180

10%, ** 5%, *** 1% Significance levels.
Standard deviations are in parenthesis.

CF/K is the ratio of the Cash Flow at time t to the Capital Stock at the end of t-1 period. CS/K is the ratio of the Changes in Sales at time t to the Capital Stock at the end of t-1 period. Change in Sales at time t is defined as the difference between Sales in time t and Sales in time t-1. (CS/K)(-1) is the 1 lagged value of the previously explained variable. Since we have continuously balanced data for Tradable sample for 1992-2003 we have results for balanced data. However, for the Non-tradable sample we have the balanced data only for 1996-2003 and unbalanced data for 1992-2003 and give results of both balanced and unbalanced data.

Table 5: Cash Flow Regression: Stock Market Firms: Turkey: 1993-1997

Dependent variable**: Investment/Capital Stock (I/K)**						
	ALL		**NT**		**T**	
	1	**2**	**1**	**2**	**1**	**2**
M/B	0.001		-0.001		0.014	
	(0.008)		(0.014)		(0.011)	
CF/K	-0.002	-0.002	-0.002	-0.002*	-0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)
CS/K		0.007***		0.005**		0.028***
		(0.003)		(0.002)		(0.007)
Intercept	0.009	0.031	0.086*	0.0733	-0.028	-0.003
	(0.025)	(0.009)	(0.0484)	(0.019)	(0.033)	(0.010)
Adj. R^2	0.800	0.324	0.185	0.234	0.825	0.395
#of Obs.	422	456	163	169	256	284

* 10%, ** 5%, *** 1% Significance levels.
Standard deviations are in parenthesis.

M/B is the Market to Book ratio. CF/K is the ratio of the Cash Flow at time t to the Capital Stock at the end of t-1 period. CS/K is the ratio of the Changes in Sales at time t to the Capital Stock at the end of t-1 period. Change in Sales at time t is defined as the difference between Sales in time t and Sales in time t-1.

Table 6: Parameter Values

α	0.4
δ	0.1
r	0.04
β	0.90
γ	0.90
h	0.2
ε	0.0007

FIGURE 5

Temporary Borrowing Coefficient Shock - Linearization

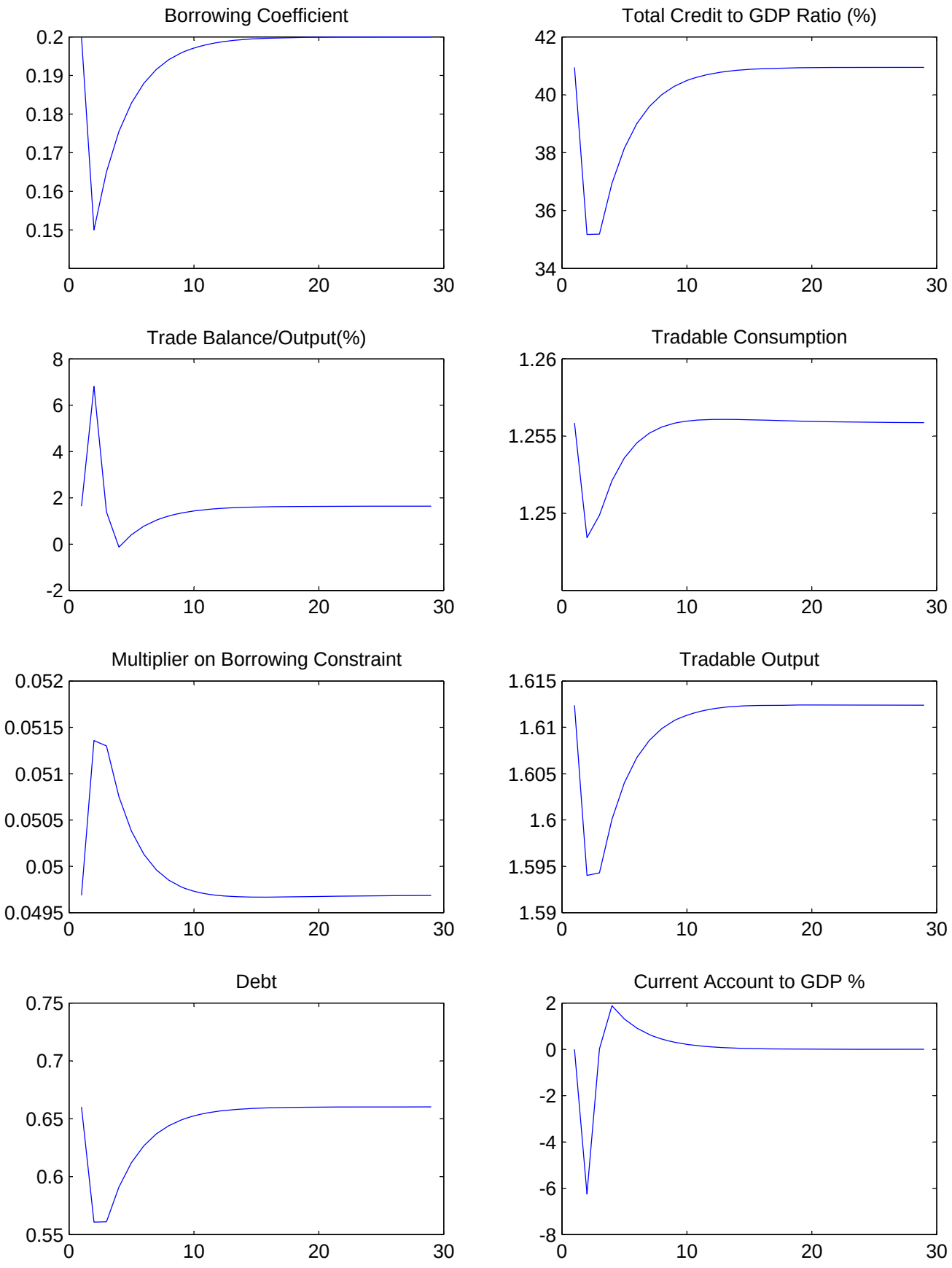
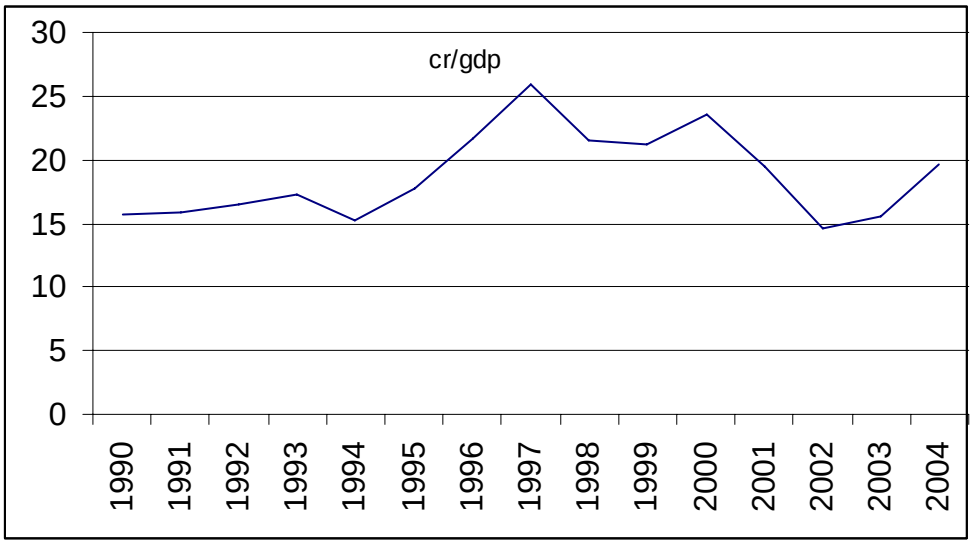
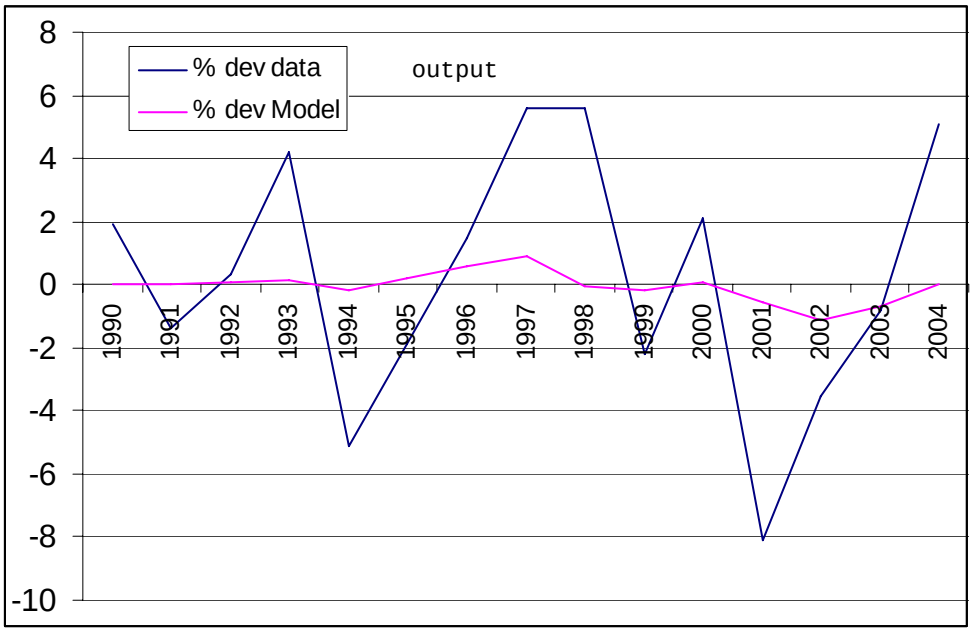
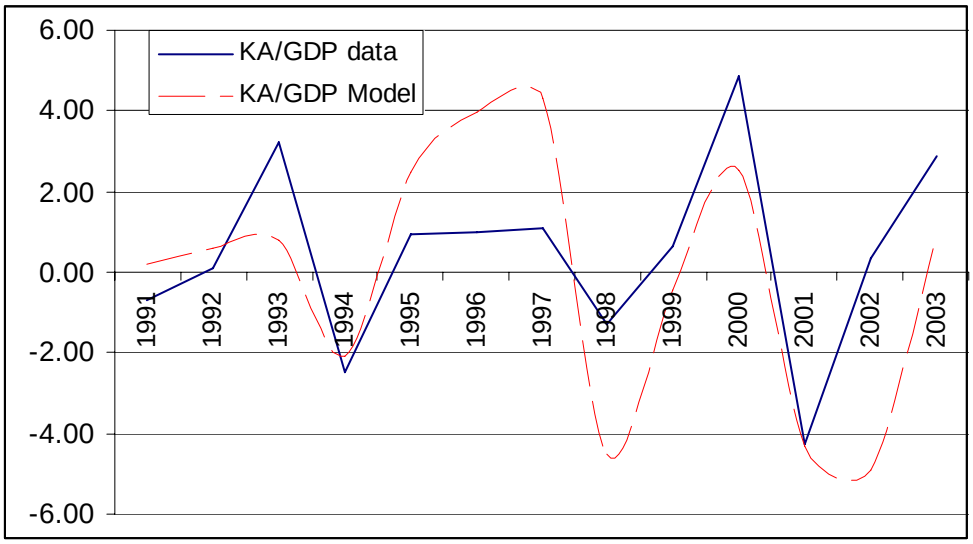


FIGURE 5

ONE GOOD ECONOMY—CALIBRATED SHOCKS TO CREDIT







Temporary Shock to NT-Borrowing Coefficient -- Linearization

FIGURE 7

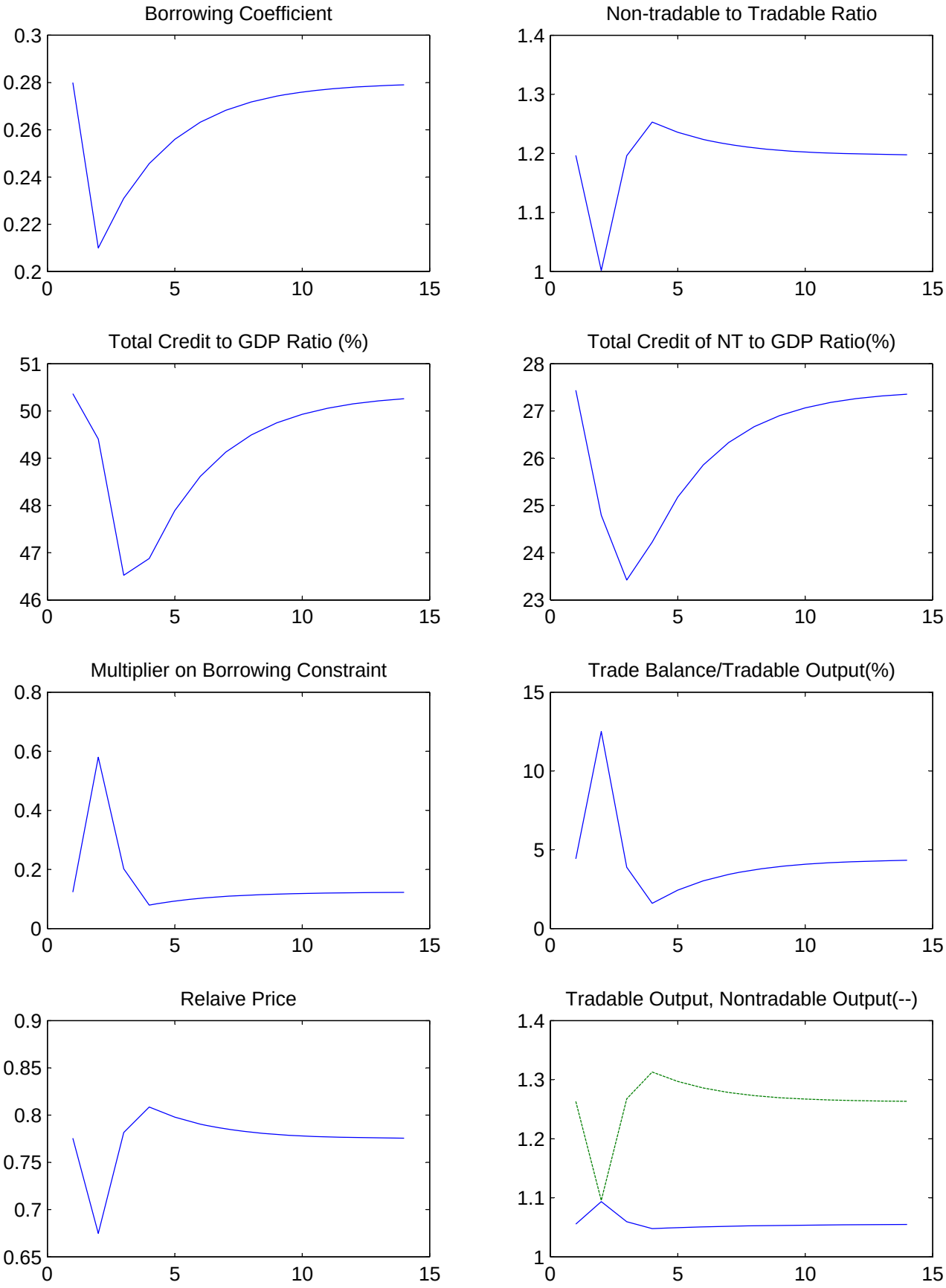


FIGURE 7

Temporary Shock to International Interest Rate --
Linearization

FIGURE 8

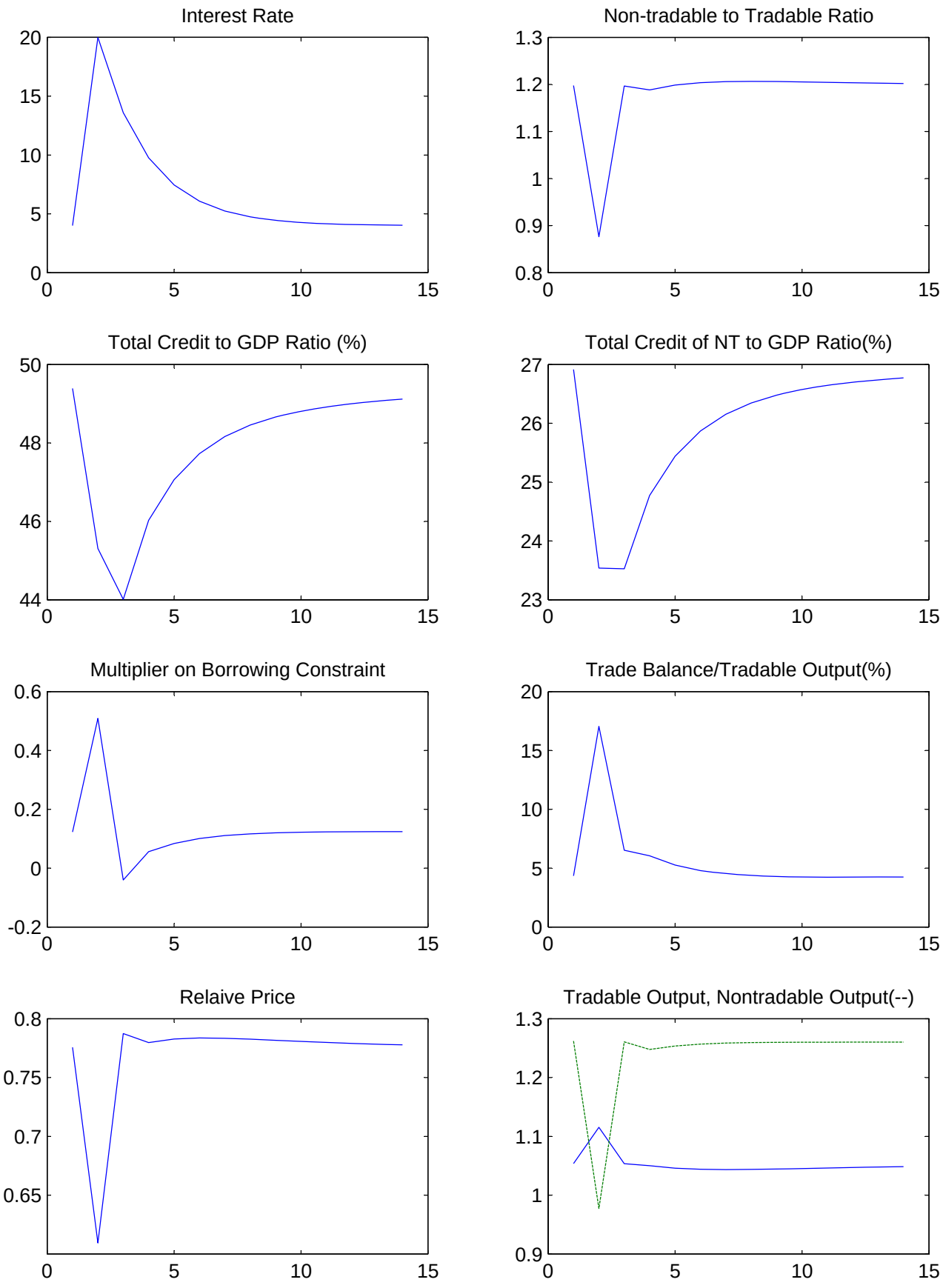
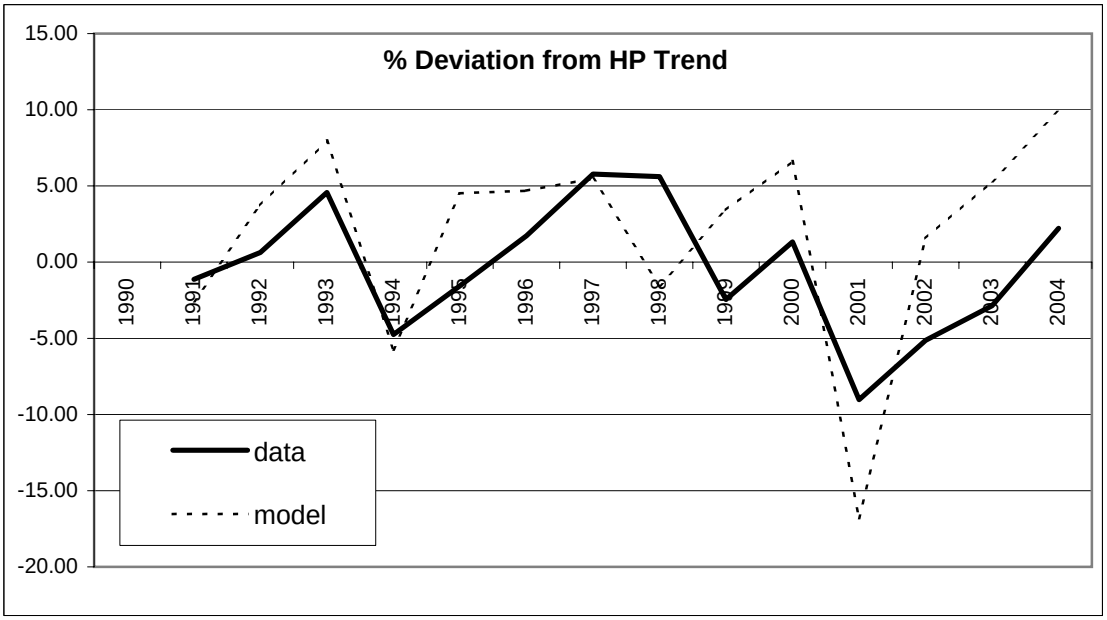


FIGURE 8

Figure 9 : TURKEY



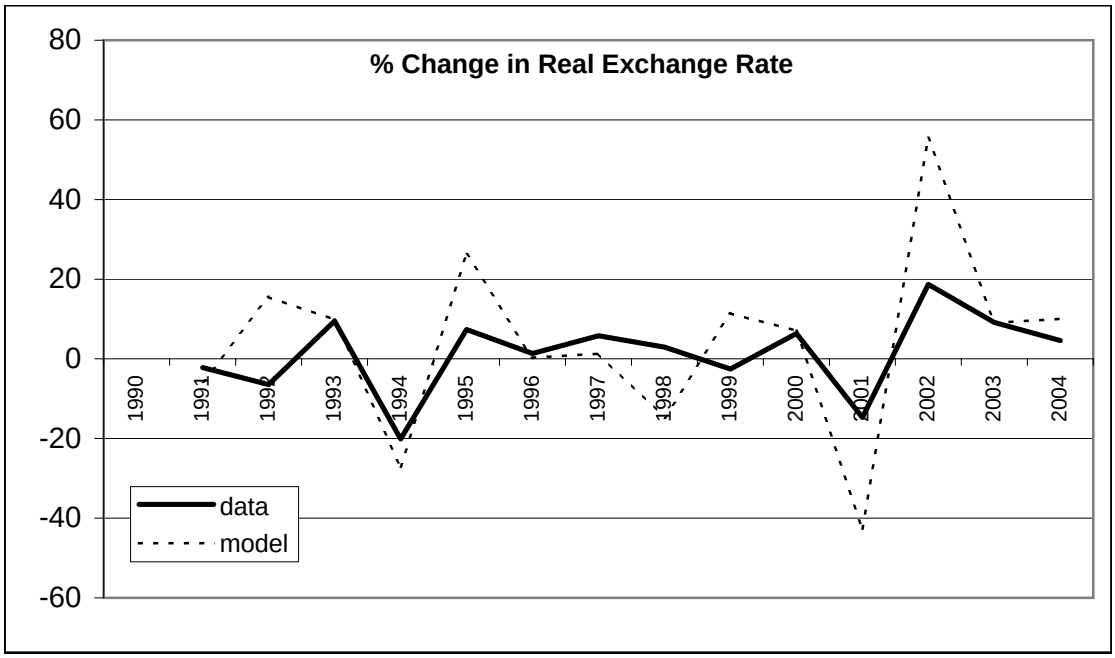


Figure 10 : Korea and Mexico: % Deviations from HP Trend