# Essays on Business Cycles in Developing Countries

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# ESSAYS ON BUSINESS CYCLES IN DEVELOPING COUNTRIES

a dissertation

by

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# ESSAYS ON BUSINESS CYCLES IN DEVELOPING COUNTRIES

-Dissertation Abstract-

by

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My dissertation consists of three papers on business cycles in developing countries. All the papers are different from each other and emphasize different aspects of understanding economic fluctuations in developing countries.

The first paper is titled 'Medium Term Business Cycles in Developing Countries' (with Diego Comin, Norman Loayza and Luis Serven). This paper models the link between business cycle fluctuations in developed countries with fluctuations in developing countries. Business cycle fluctuations in developed economies tend to have large and persistent effects on developing countries. We study the transmission of business cycle fluctuations from developed to developing economies with a two-country asymmetric DSGE model with two important features: (i) endogenous and slow diffusion of technologies from the developed to the developing country, and (ii) adjustment costs to investment flows. Consistent with the model, we observe that the flow of technologies from developed to developing economies co-moves positively with output in both developed and developing countries. After calibrating the model to Mexico and the U.S., it can explain the following stylized facts: (i) U.S. and Mexican output co-move more than consumption; (ii) U.S. shocks have a larger

effect on Mexico than in the U.S.; (iii) U.S. business cycles lead over medium term fluctuations in Mexico; (iv) Mexican consumption is more volatile than output.

The second paper of my dissertation is based on a price setting survey conducted by the State Bank of Pakistan (Central Bank). The paper is titled 'Price-Setting Discoveries: Results from a Developing Country' (with M. Ali Choudhary, Abdul Faheem, Nadeem Hanif, and Saima Naeem) present the results of 1189 structured face-to-face interviews about price-setting behavior of the formal firms in the manufacturing and services sector of Pakistan. The key findings of the survey are:the frequency of price change is high in Pakistan, lowering the real impact of monetary policy. Price rigidity is mainly explained by firms caring about relative prices and the persistence of shocks. The exchange-rate and cost shocks are more important than financial and demand shocks for both setting prices and also the readiness with which these shocks pass-through to the economy. Formal sector firms with connections to the informal sector, especially through demand, have a lower probability of price adjustment. The lack of taxes and compliance with tax regime, i.e. enforcement are held responsible for existence of the informal sector by formal sector firms. The results from this paper provided motivation for the last paper of my dissertation about understanding and modeling the business cycle fluctuations in a developing economy like Pakistan.

The last paper of my dissertation is titled 'Modeling Business Cycles in Pakistan: A First Step'. In this paper, I establish the nature of short-run fluctuations of the Pakistani economy over the period of 1960-2010. There have been significant changes in the nature of the Pakistani economy over the last few decades. Therefore, I focus my detailed analysis on the last few decades where it seems more appropriate to investigate the nature and causes

of business cycles in Pakistan. Furthermore, I evaluate the performance of a typical RBC and an augmented RBC model with an exogenous FDI shock in explaining cyclical fluctuations experienced by the Pakistani economy. I find that a simple RBC model does badly in terms of matching relevant second order moments of short run fluctuations as depicted by the data. However, augmented RBC model performs better compared to the simple RBC model.

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I dedicate this dissertation to my mother Naheed Pasha.

# Contents

# Chapter 1

# Medium Term Business Cycles in Developing Countries

## 1.1 Introduction

> "Poor Mexico! So far from God and so close to the United States."
>
> Attributed to Dictator Porfirio Diaz, 1910.

This paper explores the transmission of business cycle fluctuations for developed to developing economies. Business cycle fluctuations in developed economies tend to have strong effects on developing countries as has become clear during the great recession of 2008. When studying more generally the co-movement patterns, we observe evidence that the effects of business cycles in developed economies ($N$) on developing ($S$) ones are not only large but also quite persistent. In particular, they affect output in developing countries over the medium term and not only at business cycle frequencies.

A natural channel for the transmission of shocks from $N$ to $S$ is through $N$'s demand for $S'$ exports. Below we show, however, that this mechanism is unable to propagate shocks to $S$ with the strength and persistence we observe in the

data. We explore a different channel: the cyclicality of the speed of diffusion of new technologies embodied in new capital goods from $N$ to $S$. Following Broda and Weinstein (2006) we measure technology diffusion by the number of different (durable-manufacturing) SIC categories in which $N$ exports to $S$. We uncover two main facts. First, the number of technologies exported from $N$ to $S$ co-moves positively with $N's$ cycle, both at high frequency and at lower frequencies. Second, at low frequencies, the range of technologies imported from $N$ leads $S$ productivity measures.

To explore the quantitative implications of these regularities for business cycles in developing economies, we build a real business cycle model. Our model has two asymmetric countries with endogenous productivity growth and adjustment costs to investment. Investment adjustment costs allow us to capture the extensive micro evidence on investment frictions in developing countries (e.g. Gelos and Isgut, 2001; Iscan, 2000; Warner 1992, 1994). To endogenize productivity dynamics, we use a variation of Comin and Gertler's (2006) model of R&D and technology diffusion. As in Comin and Gertler (2006) we have endogenous development of new technologies in $N$, but we expand their framework to a two-country setting and introduce endogenous international diffusion of technologies. In particular, exporters from $N$ need to incur a sunk cost before starting to sell the intermediate goods that embody the technology in $S$. By making productivity endogenous in this way, we provide a unified account of the dynamics of productivity in $N$ and $S$ over high and low frequencies.[1] To close the lifecycle of intermediate goods, we introduce foreign direct investment (FDI) from $N$ to $S$. This allows us to capture realistically

[1] Another reason for this strategy is that many authors have questioned the importance of high frequency technology shocks and argued that short term fluctuations in the Solow residual reflect unmeasured input utilization and imperfect competition as opposed to true technology shifts (e.g. Burnside et al., 1995; Basu, 1996). Endogenous productivity, however, provides an avenue through which transitory non-technological shocks induce low frequency fluctuations in productivity without having to rely on exogenous shifts in technology.

the nature of capital flows to developing countries, of which, since 1990, 70% have been in the form of FDI (Loayza and Serven, 2006).[2]

It is well known (e.g. Comin and Hobijn, 2010) that developing countries adopt new technologies with significant time lags relative to their invention date. In our model these lags vary endogenously with the cycle. Contractionary shocks to either $N$ and to $S$ reduce the present discounted value of transferring a new technology to $S$, inducing pro-cyclical fluctuations in the speed of technology diffusion. Because technology is a state variable and changes slowly, the fluctuations in $S'$ stock of technologies occur only at low frequencies. Realistically, technologies in the model are embodied in new capital. As the number of technologies in $S$ (relative to the balanced growth path) declines, the cost of producing new investment goods in $S$ slowly increases. In the presence of adjustment costs, these prospects about the cost of investment induce companies in $S$ to start cutting investment when $N$ starts contracting. As a result, a recessionary shock to $N$ generates a contemporaneous collapse of investment and output in $S$.

In section 4, we calibrate the model to match key moments of the U.S. and Mexican economies over the last two decades. The simulations show that our model does a reasonably good job in characterizing the key features of the short and medium term fluctuations in Mexico. In doing so, it sheds light on several important open questions in international macroeconomics.

First, unlike many RBC models (e.g. Backus, Kehoe and Kydland, 1992) our model generates a higher cross-country correlation of output than that of consumption. It does so because what drives the short term cross-country co-movement in output is the pro-cyclical response of Mexico's investment to U.S. shocks. Mexico's consumption, on the other hand, does not respond

[2]The FDI share is even larger when restricting attention to private capital flows and when focusing in Latin America and Asia.

much contemporaneously to U.S. shocks. Second, our model also generates a large initial response of $S$ GDP to $N$ shocks, which helps explain why business cycle fluctuations are larger in developing than in developed economies. Third, consistent with the data, short term fluctuations in $N$ produce cycles in $S$ at frequencies lower than those of the conventional business cycle. This occurs as the initial shock in $N$ triggers a persistent slowdown in the flow of new technologies to $S$.

Fourth, the model generates counter-cyclical interest rates in $S$ endogenously in response to domestic shocks. As shown by Neumeyer and Perri (2005), an important feature of business cycles in developing countries is the counter-cyclicality of real interest rates. Based on this evidence, numerous authors have used shocks to interest rates in developing countries as a source of business cycles. In our model, the procyclical diffusion of technologies generates counter-cyclical fluctuations in the relative price of capital. These result in counter-cyclical capital gains from holding a unit of capital that dominate the pro-cyclical response of the marginal product of capital (i.e. the dividend), thus inducing interest rates in $S$ (as well as the interest differential with respect to $N$) to be counter-cyclical. Finally, the counter-cyclical response of domestic real interest rates to $S$' shocks is key for our model to rationalize a key regularity about business cycles in developing countries, namely that consumption is more volatile than output (Aguiar and Gopinath, 2007).

The endogenous international diffusion of technologies emphasized in our framework is a different phenomenon from production sharing (e.g. Bergin et al. 2009; Zlate, 2010). Production sharing models generate large fluctuations in output in $S$ in response to a shock in $N$ by assuming strong cyclicality of wages.[3] Firms in $N$ compare wages domestically and abroad and expand

[3]Another important assumption of production sharing models, though more plausible, is that the share of manufacturing is larger in $S$ than in $N$.

and contract their offshoring arrangements by increasing the extent of traded intermediates. An implication of these models is that the flow of intermediate exports from $N$ to $S$ should be pro-cyclical with respect to $N's$ cycle but counter-cyclical with respect to $S$. In contrast, in our framework both recessions in $N$ and $S$ reduce the present discounted value of future profits from exporting a new intermediate good to $S$. As a result, the flow of new technologies from $N$ to $S$ is pro-cyclical with respect to both countries, and in particular to $S$. The data examined here shows strong evidence of the pro-cyclicality of the flow of new technologies with respect to $S$. A related issue is that it is unlikely that production-sharing models or models of entry and trade in varieties (e.g. Ghironi and Melitz, 2005) can account for the low-frequency effects of $N's$ business cycle on $S's$ productivity and output we observe in the data.[4] However, we show that endogenous technology diffusion dynamics can generate the low-frequency international propagation that characterizes the data.

The rest of the paper is organized as follows. The next section presents some basic stylized facts. Section 3 develops the model. Section 4 evaluates the model through some simulations and provides intuition about the role of the different mechanisms. Section 5 discusses the results, and section 6 concludes.

[4] As we show in section 5, a key difference with trade in variety models is that the costs of affecting the extensive margin are fixed but not sunk. Modeling the transfer of technology as a sunk investment introduces a new state variable that changes the propagation and amplification of the shocks very significantly.

## 1.2 The cyclicality of international technology diffusion

In this section, we explore the role of technology diffusion in the propagation of business cycles from developed ($N$) to developing ($S$) countries. We focus on the two largest developed economies as $N$-countries: the U.S. and Japan.[5] We then select the $S$-countries based on the concentration of their (durable goods) imports from $N$.[6] That is, for each developing country without missing data and with a population of more than 2 million people, we construct an index of concentration of imports from each of the two $N$-countries. The index is just equal to the durable manufacturing imports from $N$ over total imports of durable manufacturing. For each country $N$, we select the 10 developing countries with the highest concentration.[7]

We collect data on three variables. First GDP per working age person as a measure of output both in $N$ and $S$. Next, following Greenwood and Yorukoglu (1997) and Greenwood, Hercowitz and Krusell (1997), we measure the level of embodied productivity in $S$ by ratio of the GDP deflator over the investment deflator. Finally, following Broda and Weinstein (2006), we measure the range of technologies that diffuse internationally from $N$ to $S$ by the number of 6-digit SIC codes within durable manufacturing that have exports from $N$ to $S$ that are worth at least \$1 million.

Our data are annual and cover the period 1960-2008. We use the full sam-

[5]We do not include the EU because it has a lower syncronization of the business cycles betwen its members than U.S. states or Japanese prefactures.

[6]The emphasis on durable manufacturing goods is driven by the model and because durable manufacturing goods surely embody more productive technologies than the average non-durable good. Having said that, the list of developing countries would be very similar if we ranked countries by concentration in imports or trade.

[7]The developing countries linked to the U.S. are Mexico, Dominican Republic, Costa Rica, Paraguay, Honduras, Guatemala, Venezuela, Peru, El Salvador and Nicaragua. The countries linked to Japan are Panama, Thailand, South Korea, Philippines, Vietnam, China, Pakistan, Indonesia, South Africa and Malaysia.

ple period to obtain the filtered series. However, as we explain below, we explore the properties of the filtered series over the period 1990-2008. Because we want to allow for the possibility that shocks to $N$ have a very persistent effect in $S$, we analyze fluctuations at medium term frequencies in addition to conventional business cycles. Following Comin and Gertler (2006), we define the medium term cycle as fluctuations with periods smaller than 50 years. The medium term cycle can be decomposed into a high frequency component and a medium term component. The high frequency component captures fluctuations with periods smaller than 8 years while the medium term component captures fluctuations with periods between 8 and 50 years. We use a Hodrick-Prescott filter to isolate fluctuations at the high frequency.[8] We isolate the medium term component and the medium term cycle using a band pass filter.

Two points are worth keeping in mind. First, it is important to be careful about the mapping between the frequency domain and the time domain. In principle, our measure of the cycle includes frequencies up to 50 years. However, Comin and Gertler (2006) have shown that its representation in the time domain leads to cycles on the order of a decade, reflecting the distribution of the mass of the filtered data over the frequency domain. For example, in the U.S. postwar period there are ten peaks and throughs in the medium term component of the cycle.[9] Second, despite their frequency, medium term cycles identified with macro series of conventional length are statistically significant (Comin and Gertler, 2006). We investigate the significance of the medium term component of per capita income in the countries in our sample by constructing confidence intervals using a bootstrap procedure.[10] We find that

[8]The HP-filtered series are very similar to the series that result from using a Band-Pass filter that keeps fluctuations with periodicity smaller than eight years (Comin and Gertler, 2006). We use the HP filter to isolate high-frequency fluctuations to make our findings more comparable to the literature.

[9]There are 22 peaks and throughs at conventional frequencies.

[10]Specifically, we use the bootsrap method described in Comin and Gertler (2006). Es-

52% of annual observations of the filtered series are statistically significant at 95% level. By way of comparison, we find that 80% of the HP-filtered annual observations are significant. Therefore, we consider that inferences based on series filtered to isolate medium term fluctuations are statistically informative.

After filtering the macro variables, we study their co-movement patterns for the period 1990-2008. We focus on this period for two reasons. First, the volume of trade and FDI inflows to developing countries increased very significantly during this period, making the mechanisms emphasized by our model more relevant than before. Second, after 1990, FDI became the most significant source of capital inflows from developed to developing economies, making our model's assumptions about the nature of international capital flows most appropriate for this period (Loayza and Serven, 2006).

Before analyzing the data, an example can be useful to illustrate the co-movement patterns between developed and developing countries. Figure 1A plots the series of HP-filtered GDP in the U.S. and Mexico. The contemporaneous cross-country correlation is 0.42 (with a p-value of 7%). U.S. business fluctuations such as the internet-driven expansion during the second half of the 1990s, the burst of the dot-com bubble in 2001, the 2002-2007 expansion and the 2008 financial crisis are accompanied by similar fluctuations in Mexico. Arguably, none of the shocks that caused these U.S. fluctuations originated in Mexico. Therefore, it is natural to think that the co-movement between Mexico and U.S. GDP resulted from the international transmission of U.S. business cycles.[11]

The effects of U.S. business cycles on Mexico's GDP are very persistent

sentially, the method consists in padding the time series at both ends, and filtering the extended series. Then, for each period in the original series, we build a 95% confidence interval.

[11]The only important Mexican shock over this period was the 1995 recession which, despite its virulence, was relatively short-lived.

and go beyond conventional business cycle frequencies. Figure 1B plots the medium term component of Mexico's GDP together with HP-filtered U.S. GDP. The lead-lag relationship between these variables can be most notably seen during the post 1995 expansion, the 2001 recession and the post-2001 expansion. Despite the severity of the effect of the Tequila crisis on the medium term component of Mexico's GDP, the latter strongly recovered with the U.S. post-1995 expansion. The Mexican medium term recovery lagged the U.S. boom by about two years. The end of Mexico's expansion also lagged the end of the U.S. expansion by one year. Finally, the post-2001 U.S. expansion also coincided with a boom in the medium term component of Mexico's GDP which continued to expand as late as 2008.

Table 1A explores more generally these co-movement patterns using our panel of countries. The first row reports the coefficient $\beta$ from the following regression:

$$HPy_{Sct} = \alpha + \beta * HPy_{Nct-k} + \epsilon_{ct}$$

where $HPy_{Sct}$ is HP-filtered output in developing country $c$, and $HPy_{Nct-k}$ is HP-filtered output in the developed economy associated with $c$ lagged $k$ years. We find that an increase by 1% in $N's$ output is associated with an increase by 0.42% in $S'$ output. This effect declines monotonically and becomes insignificant when $k = 2$.

The second row of Table 1A reports the coefficient $\beta$ from the following regression:

$$MTCy_{Sct} = \alpha + \beta * HPy_{Nct-k} + \epsilon_{ct}$$

where $MTCy_{Sct}$ is the medium term component of the medium term cycle of output in developing country $c$. High frequency fluctuations in output in $N$ are associated with even larger fluctuations in the medium term component of

output in $S$. A 1% higher level of HP-output in $N$ is associated with a 0.63% higher medium term component of output in $S$. This association increases when we lag the impulse in $N$ by one year and remains the same when we lag it by two years. Note that, if the medium term cycle in $S$ was just an average of the short term fluctuations, we would tend to find smaller $\beta's$ in the second row than in the first one. Hence, Table 1A suggests that short term fluctuations in $N$ affect mechanisms that induce fluctuations in $S$ at frequencies below the conventional business cycle. What are those mechanisms?

Table 1B shows that business cycle fluctuations in $N$ are positively associated with fluctuations in the number of durable manufacturing goods exported from $N$ to $S$. Since many new technologies are embodied in new durable manufacturing goods, this correlation suggests that the speed of diffusion of new technologies from $N$ to $S$ co-moves with $N$'s cycle. Table 1B also shows a strong co-movement between the flow of these technologies and the cycle in $S$.

Table 1C then explores the potential impact of fluctuations in the range of technologies imported on $S$' output and productivity over the medium term. Specifically, it shows that when looking at the medium term component of the medium term cycle, the range of durable manufacturing goods exported from $N$ to $S$ is significantly correlated with output in $S$. One reason for this finding is that, at relatively low frequencies, the range of capital goods imported from $N$ is a key driver of productivity in $S$. The second row of Table 1C presents further evidence on this hypothesis. An increase in the range of durable manufacturing goods imported from $N$ leads to a lower price of investment goods in $S$. This association becomes more negative as we increase the lag in the range of intermediate goods. This may reflect the fact that newly adopted technologies by $S$ do not diffuse immediately among producers in $S$.

It is important to remark that, even if statistical agencies do not do a good

job in adjusting their price deflators for gains from variety, one would expect the relative price of investment to reflect the gains from variety if the imported intermediate goods are used to produce new investment. This will occur not because statisticians recognize the productivity enhancing benefits from the goods at the border but because (capital goods) producers that use the new technologies will experience lower production costs that should be reflected in lower capital goods prices.

The picture that emerges from this simple exploration of the data is that the persistent effect of business cycles in developed economies on their developing partners may be mediated by the pro-cyclical fluctuation in the speed of international technology diffusion, which affects the productivity in developing economies over the medium term. Next, we explore the effects of introducing this transmission mechanism into a real business cycle model.

## 1.3 Model

We now develop a two-country model of medium term business fluctuations. We denote the countries by North, $N$, and South, $S$. The model is annual as opposed to quarterly because, as noted earlier, we are interested in capturing fluctuations over a longer horizon than is typically studied. To this end, we abstract from a number of factors that may be important to understand quarterly dynamics such as money and nominal rigidities.

Our model is a version of a conventional real business cycle model modified to allow for endogenous productivity and relative price of capital. To capture the short-term counter-cyclicality of the relative price of capital, we introduce two sectors and endogenous entry and exit. An alternative approach, with similar results, would be to allow for counter-cyclical markups as in Rotemberg

and Woodford (1995).

We endogenize productivity by introducing endogenous R&D and international diffusion of technologies. Technologies are embodied in intermediate goods. Productivity depends on the number of intermediate goods available for production. As in the product cycle literature (e.g. Vernon, 1966; Wells, 1972; and Stokey, 1991), intermediate goods are invented in $N$ as a result of R&D investments. After the producer incurs a stochastic (sunk) investment, the good can be exported to $S$ (i.e. it diffuses to $S$). After a final stochastic investment, which we interpret as FDI, the production of the intermediate good is transferred to $S$ and the good is exported from $S$ to $N$.

Households are conventional. Exogenous shocks to the disutility from working drive fluctuations. Following Hall (1997) and others, we interpret these disturbances as a reduced form of more fundamental forces that affect the degree of rigidities in labor markets (i.e. wage markups).

We first describe the endogenous evolution of technology. We then discuss the production of capital and output and the household's problem. Finally, we characterize the complete equilibrium.

### 1.3.1 Technology

The sophistication of the production process in country $c$ depends on the number of intermediate goods available for production, $A_{ct}$. There are three types of intermediate goods. There are $A_t^l$ local intermediate goods that are only available for production in $N$. There are $A_t^g$ global intermediate goods that have successfully diffused to $S$. These goods are produced in $N$ and exported to $S$, and are available for production in both $N$ and $S$. There are $A_t^T$ intermediate goods whose production has been transferred to $S$. These goods are exported from $S$ to $N$ and are available for production in both $N$ and $S$. The

total number of intermediate goods in each country is therefore given by

$$A_{Nt} = A_t^l + A_t^g + A_t^T, \text{ and} \tag{1.1}$$

$$A_{St} = A_t^g + A_t^T. \tag{1.2}$$

Next, we present the conditions that characterize the technology dynamics in each economy.

*Creation of New Intermediate Goods.*– Innovators in $N$ engage in R&D by investing final output to develop new intermediate goods. Each innovator, $p$, has access to the following technology:

$$A_{Nt+1}(p) - A_{Nt}(p) = \varphi_t S_t(p) - (1-\phi)A_{Nt}(p), \tag{1.3}$$

where $A_{Nt}(p)$ denotes her stock of invented goods, $S_t(p)$ are her expenditures in R&D, $(1-\phi)$ is the per-period probability that an intermediate good becomes obsolete, and $\varphi_t$ represents the productivity of the R&D technology, which is taken as given by the innovator.

We assume that $\varphi_t$ depends on the aggregate stock of intermediate goods in $N$, $A_{Nt}$, the medium term wholesale value of the capital stock, $\overline{P}_{Nt}^k K_{Nt}$, – to be defined below[12] – and aggregate R&D expenses, $S_t$, as follows:

$$\varphi_t = \chi A_{Nt} \left( \frac{S_t}{\overline{P}_{Nt}^k K_{Nt}} \right)^{\rho-1} (\overline{P}_{Nt}^k K_{Nt})^{-1}, \tag{1.4}$$

with $0 < \rho \leq 1$ and where $\chi$ is a scale parameter. This formulation is borrowed from Comin and Gertler (2006) and allows us to calibrate the elasticity of innovations with respect to R&D expenditures to match the data. In addition, it ensures the existence of a balanced growth path without scale effects.

[12]Roughly speaking it corresponds to the value of the capital stock priced at the cost of production faced by individual producers of investment goods.

After developing a new technology, the innovator is granted a patent that protects her rights to the monopolistic rents from selling the good that embodies it. These rents have a market value of $v_t$. In equilibrium, agents engage in R&D activities until the cost of developing a new intermediate good (LHS) equalizes its expected market value (RHS):

$$1/\varphi_t = \phi \mathbb{E}_t \left[ \Lambda_{Nt+1} v_{t+1} \right], \tag{1.5}$$

where $\Lambda_{Nt+1}$ is the innovator's stochastic discount factor for returns between $t$ and $t+1$.

Equation (1.5) strongly hints at how the framework generates pro-cyclical R&D. When $N$ experiences a recession, the expected value of a new local intermediate good, $\mathbb{E}_t v_{t+1}$, declines. That is, since the profit flow for local goods declines, the benefit to creating new varieties of intermediate goods goes down. R&D spending will decline in response.

*International Diffusion.–* Producers of local intermediate goods have the option of engaging in a stochastic investment that, if successful, permits the diffusion of the intermediate good to $S$. The probability of succeeding in this investment is $\lambda(\Gamma_t^g x_t^g)$, where the function $\lambda(.)$ satisfies $\lambda' > 0$, $\lambda'' < 0$, $x_t^g$ is the amount of final output invested, and $\Gamma_t^g$ is a scaling factor.[13] We model $\Gamma_t^g$ so that it adjusts slowly to guarantee balanced growth.

$$\Gamma_t^g = \frac{b^g}{(\overline{P}_{Nt}^k K_{Nt}/A_t^l)}, \text{ with the constant } b^g > 0. \tag{1.6}$$

The market value of a local intermediate good reflects both the present

[13] We do not have to take a strong stand on who engages in the investments in exporting and in transferring the production of the goods to $S$. For expositional purposes, we assume it is the innovator, but the model is isomorphic to one where he auctions the patent and somebody else is in charge of making these investments afterwards.

discounted value of local profits as well as the value of the option to become global as shown in the following Bellman equation:

$$v_t = \max_{x_t^g} \pi_t - x_t^g + \phi \mathbb{E}_t \left\{ \Lambda_{Nt+1} \left[ \lambda \left( \Gamma_t^g x_t^g \right) v_{t+1}^g + \left( 1 - \lambda \left( \Gamma_t^g x_t^g \right) \right) v_{t+1} \right] \right\}, \quad (1.7)$$

where $\pi_t$ denotes the per period profits of a local intermediate goods producer and $v^g$ is the market value of a global intermediate good. At any given period, $v^g$ is greater than $v$ because global goods producers enjoy a profit stream from selling goods at both $N$ and $S$. Shipping the goods internationally involves an iceberg transport cost. In particular, $1/\psi$ (with $\psi < 1$) units of the good need to be shipped so that one unit arrives.

The optimal investment, $x^g$, equalizes, at the margin, the cost and the expected benefits of exporting the intermediate good to $S$ as shown in the following first order condition:

$$1 = \overbrace{\Gamma_t^g \lambda' \left( \Gamma_t^g x_t^g \right)}^{\text{Mg. } \triangle \text{ in } \lambda^g} \overbrace{\mathbb{E}_t \left\{ \phi \Lambda_{Nt+1} \left( v_{t+1}^g - v_{t+1} \right) \right\}}^{\triangle \text{ in value}}. \quad (1.8)$$

The marginal cost of investing one unit of output in exporting the good (LHS) is 1, while the expected marginal benefit is equal to the associated increase in the probability of international diffusion times the discounted gain from making the intermediate good global.

It is now easy to see why expenditures on the international diffusion of technologies will move procyclically. During recessions, the value of a global intermediate good declines by more than the value of a local intermediate good (i.e. $(v_{t+1}^g - v_{t+1})$ declines). In this case, $x_t^g$ will decline since the return to investing in exporting intermediate goods goes down. The reverse, of course, will happen during booms.

The value of an intermediate good, $v_t^g$, is given by

$$v_t^g = \max_{x_t^T} \pi_t^g - e_t x_t^T + \phi \mathbb{E}_t \left\{ \Lambda_{Nt+1} \left[ \lambda \left( \Gamma_t^T x_t^T \right) v_{t+1}^T + \left( 1 - \lambda \left( \Gamma_t^T x_t^T \right) \right) v_{t+1}^g \right] \right\}, \tag{1.9}$$

where $\pi_t^g$ denotes the per period profits of a global intermediate goods producer, $x_t^T$ is the number of units of country $S'$s final output spent in transferring the production of the intermediate good to $S$, $\lambda(\Gamma_t^T x_t^T)$ is the associated probability of successfully completing this foreign direct investment, where the function $\lambda(.)$ satisfies $\lambda' > 0$, $\lambda'' < 0$, $e_t$ is the exchange rate (dollars per peso), $v^T$ is the market value of the company that produces a transferred intermediate good, and $\Gamma_t^T$ is a scaling factor, taken as exogenous by the innovator and equal to

$$\Gamma_t^T = \frac{b^T}{(\overline{P}_{Nt}^k K_{Nt} / A_t^g)}. \tag{1.10}$$

*Foreign Direct Investment.–* The South has comparative advantage in assembling manufacturing goods (e.g. Iyer, 2005). In particular, it takes one unit of final output to produce a unit of intermediate good in $N$, while if the intermediate good is assembled in $S$, it only takes $1/\xi (< 1)$ units of country $S$ output. This cost advantage results in higher profit flows from transferred global intermediate goods than from global intermediate goods (i.e. $\pi_t^T > \pi_t^g$), and induces producers of global intermediate goods to transfer the production of intermediate goods from $N$ to $S$.

The optimal intensity of FDI, $x_t^T$, equalizes the private marginal costs and expected benefits of transferring the production to $S$. The marginal cost is $e_t$, while the expected marginal benefit is the increase in the probability of succeeding in the FDI times the discounted gain from transferring the production

of the intermediate good to $S$. Formally,

$$e_t = \overbrace{\Gamma_t^T \lambda' \left(\Gamma_t^T x_t^T\right)}^{\text{Mg. } \triangle \text{ in } \lambda^T} \overbrace{\mathbb{E}_t \left\{\phi \Lambda_{Nt+1} \left(v_{t+1}^T - v_{t+1}^g\right)\right\}}^{\triangle \text{ in value}}, \tag{1.11}$$

where $v^T$ is defined by the following Bellman equation:

$$v_t^T = \pi_t^T + \phi E_t \left\{\Lambda_{Nt+1} v_{t+1}^T\right\}. \tag{1.12}$$

### 1.3.2 Production

*Investment.*– Investment is produced in two stages. In a first stage, a continuum of $N_{ct}^K$ differentiated capital goods producers combine the intermediate goods available in the country to manufacture their capital goods. In a second stage, the differentiated capital goods are used to produce competitively new investment. This production structure generates a counter-cyclical price of capital both in the short and in the medium term. This seems an important feature of business cycle in developing countries. In our sample of dveeloping countries, we observe that the correlation between output and the relative price of capital, both at high and medium term frequencies, is significant and around -0.2.

Let $I_{ct}(r)$ be the amount of differentiated capital produced by producer $r$, and let $I_{ct}^r(s)$ be the amount of intermediate good $s$ she demands. Then we can express the amount of differentiated capital she produces by

$$I_{ct}(r) = \left(\int_0^{A_{ct}} I_{ct}^r(s)^{\frac{1}{\theta}} ds\right)^{\theta}, \text{ with } \theta > 1. \tag{1.13}$$

Investment, $J_{ct}$, is produced competitively by combining these $N_{ct}^k$ differ-

entiated capital outputs as follows:

$$J_{ct} = \left( \int_0^{N_{ct}^K} I_{ct}(r)^{\frac{1}{\mu^K}} \, dr \right)^{\mu^K}, \text{with } \mu^K > 1. \tag{1.14}$$

Each differentiated capital goods producer holds some market power that enables her to earn monopolistic rents from selling her capital good. To be operative, capital goods producers need to incur an operating cost, $o_{ct}^k$. We assume that $o_{ct}^k$ is proportional to the sophistication of the economy as measured by the wholesale value of the capital stock:

$$o_{ct}^k = b_c^k \overline{P}_{ct}^K K_{ct}, \tag{1.15}$$

where $b_c^k$ is a positive constant.

Higher rents lead more capital goods producers to enter the production of differentiated capital goods. Free entry implies that, in equilibrium, the level of $N_{ct}^k$ is such that operating profits (LHS) equal operating costs (RHS):

$$\frac{\mu^k - 1}{\mu^k} P_{ct}^K(j) \, I_{ct}(j) = b_c^k \overline{P}_{ct}^K K_{ct}, \tag{1.16}$$

where $P_{ct}^K(j)$ is the price charged by the producer of the $j^{th}$ differentiated capital good in country $c$.

Observe from (1.13) and (1.14) that there are efficiency gains in producing new capital from increasing the number of intermediate inputs, $A_{ct}$, and of differentiated capital producers, $N_{ct}^k$. As we shall see, these efficiency gains are responsible for the counter-cyclicality of the price of new capital, $P_{ct}^K$.[14]

*Output.*– For symmetry with the capital sector, we assume that final output, $Y_{ct}$, is produced in two stages. At the first stage, each of $N_{ct}$ differenti-

[14] An alternative formulation with similar implications for the high frequency fluctuations in the relative price of capital would be to introduce counter-cyclical price markups.

ated output producers, indexed by $j$, combines capital, $K_{cjt}$, and labor, $L_{cjt}$, to produce its differentiated output, $Y_{ct}(j)$, with the following Cobb-Douglas technology:

$$Y_{ct}(j) = (1+g)^t \left(U_{cjt} K_{cjt}\right)^{\alpha} \left(L_{cjt}\right)^{1-\alpha}, \tag{1.17}$$

where $g$ is the exogenous growth rate of disembodied productivity,[15] and $U$ denotes the intensity of utilization of capital. Factor markets (i.e. labor and capital) are perfectly competitive.

At the second stage, gross output, $Y_{ct}$, is produced competitively by aggregating the $N_{ct}$ differentiated final goods as follows:

$$Y_{ct} = [\int_0^{N_{ct}} Y_{ct}(j)^{\frac{1}{\mu}} dj]^{\mu}, \text{ with } \mu > 1. \tag{1.18}$$

Differentiated final goods producers need to incur an operating cost, $o_{ct}$, to remain operative. We assume,

$$o_{ct} = b_c \overline{P}_{ct}^K K_{ct}. \tag{1.19}$$

Free entry equalizes the per period operating profits to the overhead costs determining the number of final goods firms $N_{ct}$.

$$\frac{\mu - 1}{\mu} P_{ct}(j) Y_{ct}(j) = b_c \overline{P}_{ct}^K K_{ct} \tag{1.20}$$

### 1.3.3 Households

*Households.*– In each country, there is a representative household that consumes, supplies labor and saves. It may save by either accumulating capital or lending to innovators. The household also holds equity claims in all mo-

[15] For simplicity, we assume that it is exogenous. It is quite straightforward to endogenize it as shown in Comin and Gertler (2006).

nopolistically competitive firms in the country. It makes one period loans to innovators and also rents capital that it has accumulated directly to firms. Physical capital does not flow across countries. Further, there is no other form of international lending and borrowing. This implies that $N's$ FDI in $S$ is the only item in $S's$ financial account.

Let $C_{ct}$ be consumption and $\mu_{ct}^{w}$ a shock to the disutility of working. Then the household maximizes its present discounted utility as given by the following expression:

$$\mathbb{E}_t \sum_{i=0}^{\infty} \beta^{t+i} \left[ \ln C_{ct} - \mu_{ct}^{w} \frac{(L_{ct})^{\zeta+1}}{\zeta+1} \right], \tag{1.21}$$

subject to the budget constraint

$$C_{ct} = \omega_{ct} L_{ct} + \Pi_{ct} + D_{ct} K_{ct} - P_{ct}^{k} J_{ct} + R_{ct} B_{ct} - B_{ct+1} - T_{ct} \tag{1.22}$$

where $\Pi_{ct}$ reflects the profits of intermediate goods producers paid out fully as dividends to households, $D_{ct}$ denotes the rental rate of capital, $J_{ct}$ is investment in new capital, $B_{ct}$ is the total loans the household makes at $t-1$ that are payable at $t$, and $T_{ct}$ reflects lump sum taxes. $R_{ct}$ is the (possibly state-contingent) payoff on the loans.

The household's stock of capital evolves as follows:

$$K_{ct+1} = (1 - \delta(U_{ct}))K_{ct} + J_{ct}(1 - \xi_c \left( \frac{J_{ct}}{J_{ct-1}(1+g_K)} \right)), \tag{1.23}$$

where $g_K$ denotes the steady state growth rate of capital. $\delta(U_{ct})$ is the depreciation rate which is increasing and convex in the utilization rate as in Greenwood, Hercowitz and Huffman (1988). The convex function $\xi_c(.)$ represents the adjustment costs that are incurred when the level of investment changes over time. We assume that $\xi_c(1) = 0$, $\xi_c'(1) = 0$, so that there are

no adjustment costs in the steady state.[16] Note also that the function $\xi_c(.)$ is indexed by $c$ reflecting international asymmetries in the magnitude of adjustment costs.

The household's decision problem is simply to choose consumption, labor supply, capital and bonds to maximize equation (1.21) subject to (1.22) and (1.23).

*Government.–* Government spending, $G_{ct}$, is financed every period with lump sum taxes, $T_{ct}$:

$$G_{ct} = T_{ct}. \tag{1.24}$$

## 1.4 Symmetric equilibrium

The economy has a symmetric sequence of markets equilibrium. The endogenous state variables are the aggregate capital stocks in each country, $K_{ct}$, and the stocks of local, $A_t^l$, global, $A_t^g$, and transferred, $A_t^T$, intermediate goods. The following system of equations characterizes the equilibrium.

*Resource Constraints and Aggregate Production.–* The uses of output in each country are divided into consumption, government spending, overhead costs, production of intermediate goods used in the production of new capital and investments in the creation, diffusion and transfer of intermediate goods:

[16] This is the specification for the investment adjustment costs used in Christiano, Eichembaum and Evans (2005), Jaimovich and Rebelo (2008), and Comin, Gertler and Santacreu (2009).

$$Y_{Nt} = C_{Nt} + S_t + x_t^g A_t^l + \overbrace{\frac{\mu-1}{\mu} Y_{Nt} + \frac{\mu^K - 1}{\mu^K} P_{Nt}^K J_{Nt}}^{\text{overhead costs}} + G_{Nt} \quad (1.25)$$
$$+ \underbrace{\overbrace{\frac{P_{Nt}^K J_{Nt}}{\mu^K \theta a_{Nt}} (1 + \frac{A_t^g}{A_t^l})}^{\text{intermediates sold to N}} + \overbrace{e_t \frac{P_{St}^K J_{St}}{\mu^K \theta a_{St}} \frac{A_t^g}{A_t^T} \left( \frac{\psi e_t}{\xi} \right)^{\frac{1}{\theta-1}}}^{\text{intermediates sold to S}}}_{\text{production of investment goods}}$$

$$Y_{St} = C_{St} + x_{St}^T A_t^g + \overbrace{\frac{\mu-1}{\mu} Y_{St} + \frac{\mu^K - 1}{\mu^K} P_{St}^K J_{St}}^{\text{overhead costs}} + G_{St} \quad (1.26)$$
$$+ \underbrace{\overbrace{\frac{P_{Nt}^K J_{Nt}}{e_t \mu^K \theta a_{Nt}} \frac{A_t^T}{A_t^l} \left( \frac{\psi \xi}{e_t} \right)^{\frac{1}{\theta-1}}}^{\text{intermediates sold to N}} + \overbrace{\frac{P_{St}^K J_{St}}{\mu^K \theta a_{St}} \xi^{\frac{1}{\theta-1}}}^{\text{intermediates sold to S}}}_{\text{production of investment goods}} .$$

The output produced in each country is given by

$$Y_{ct} = (1+g)^t N_{ct}^{\mu-1} (U_{ct} K_{ct})^{\alpha} E_{cjt}^{\eta} \left( L_{cjt} \right)^{1-\eta-\alpha}, \quad (1.27)$$

where the term $N_{ct}^{\mu-1}$ reflects the efficiency gains from diversity.

*Factor Markets.–* The labor market in each country satisfies the requirement that the marginal product of labor equals the product of the price markup and the household's marginal rate of substitution between leisure and consumption:

$$(1-\alpha) \frac{Y_{ct}}{L_{ct}} = \mu \mu_{ct}^w L_{ct}^{\zeta} C_{ct}. \quad (1.28)$$

The equilibrium conditions for capital and the utilization rate are, respectively:

$$\alpha \frac{Y_{ct}}{K_{ct}} = \mu \left[ D_{ct} + \delta(U_{ct}) P^I_{ct} \right] \tag{1.29}$$

$$\alpha \frac{Y_{ct}}{U_{ct}} = \mu \delta'(U_{ct}) P^I_{ct} K_{ct}. \tag{1.30}$$

*Optimal Investment.–* The stock of capital evolves according to the following law of motion:

$$K_{ct+1} = (1 - \delta(U_{ct}))K_{ct} + J_{ct}(1 - \xi_c \left( \frac{J_{ct}}{J_{ct-1}(1+g_K)} \right)) \tag{1.31}$$

The adjustment costs introduce a wedge between the price of new capital ($P^K_{ct}$) and the price of installed capital ($P^I_{ct}$) when the flow of real investment deviates from the steady state level. In particular, a reduction in investment raises the price of installed capital because the adjustment costs in (1.31) induce a higher cost of investment in the future. As a result, the optimal investment dynamics (1.32) tend to smooth out investment flows:

$$\begin{aligned} P^K_{ct} = {} & P^I_{ct} \left[ 1 - \xi_c \left( \frac{J_{ct}}{J_{ct-1}(1+g_K)} \right) - \xi'_c \left( \frac{J_{ct}}{J_{ct-1}(1+g_K)} \right) \frac{J_{ct}}{J_{ct-1}(1+g_K)} \right] \\ & + \mathbb{E}_t \left[ P^I_{ct+1} \beta \Lambda_{c,t+1} \xi'_c \left( \frac{J_{ct+1}}{J_{ct}(1+g_K)} \right) \left( \frac{J_{ct+1}}{J_{ct}(1+g_K)} \right)^2 \right]. \end{aligned} \tag{1.32}$$

*Consumption/Savings.–* We can express the intertemporal Euler equation as

$$\mathbb{E}_t \left\{ \Lambda_{c,t+1} \frac{\left[ \alpha \frac{Y_{ct}}{\mu K_{ct+1}} + (1 - \delta(U_{ct+1})) P^I_{ct+1} \right]}{P^I_{ct}} \right\} = 1, \tag{1.33}$$

where

$$\Lambda_{c,t+1} = \beta C_{ct} / C_{ct+1}. \tag{1.34}$$

Arbitrage between acquisition of capital and loans to innovators and exporters implies

$$\mathbb{E}_t\left\{\Lambda_{c,t+1}R_{t+1}\right\} = \mathbb{E}_t\left\{\Lambda_{c,t+1}\frac{\left[\alpha\frac{Y_{ct}}{\mu K_{ct+1}} + (1-\delta(U_{ct+1}))P^I_{ct+1}\right]}{P^I_{ct}}\right\}. \tag{1.35}$$

*Free Entry.*– Free entry by final goods producers in each sector yields the following relationship between operating profits and the number of final good producers:

$$\frac{\mu-1}{\mu}\frac{Y_{ct}}{N_{ct}} = b_c\overline{P}^K_{ct}K_{ct}; \tag{1.36}$$

$$\frac{\mu^K-1}{\mu^K}\frac{P^K_{ct}J_{ct}}{N^K_{ct}} = b^k_c\overline{P}^K_{ct}K_{ct}. \tag{1.37}$$

*Profits, Market Value of Intermediates and Optimal Technology Diffusion and FDI.*– The profits accrued by local intermediate good producers depend only on the demand conditions in $N$, while the profits of global and transferred intermediate goods depends also on the demand in $S$. Specifically, they are given by

$$\pi_t = \left(1-\frac{1}{\theta}\right)\frac{P^K_{Nt}J_{Nt}}{\mu_k a_{Nt}A^l_t} \tag{1.38}$$

$$\pi^g_t = \left(1-\frac{1}{\theta}\right)\frac{P^K_{Nt}J_{Nt}}{\mu_k a_{Nt}A^l_t} + \left(1-\frac{1}{\theta}\right)e_t\frac{P^K_{St}J_{St}}{\mu_k a_{St}A^T_t}\left(\frac{\psi e_t}{\xi}\right)^{\frac{1}{\theta-1}}, \tag{1.39}$$

$$\pi^T_t = \left(1-\frac{1}{\theta}\right)\frac{P^K_{Nt}J_{Nt}}{\mu_k a_{Nt}A^l_t}\left(\frac{\psi\xi}{e_t}\right)^{\frac{1}{\theta-1}} + \left(1-\frac{1}{\theta}\right)e_t\frac{P^K_{St}J_{St}}{\mu_k a_{St}A^T_t}, \tag{1.40}$$

where $a_{Nt}$ is the ratio of the effective number of intermediate goods in $N$

relative to $A_t^l$, and $a_{St}$ is the ratio of the effective number of intermediate goods in $S$ relative to $A_t^T$ :

$$a_{Nt} = \left[1 + \frac{A_t^g}{A_t^l} + \frac{A_t^T}{A_t^l}\left(\frac{\psi\xi}{e_t}\right)^{\frac{1}{\theta-1}}\right]; \tag{1.41}$$

$$a_{St} = \left[\frac{A_t^g}{A_t^T}\left(\frac{\psi e_t}{\xi}\right)^{\frac{1}{\theta-1}} + 1\right]. \tag{1.42}$$

The market value of companies that currently hold the patent of a local, global and transferred intermediate good are, respectively,

$$v_t = \pi_t - x_t^g + \phi\mathbb{E}_t\left\{\Lambda_{N,t+1}\left[\lambda\left(\Gamma_t^g x_t^g\right)v_{t+1}^g + \left(1-\lambda\left(\Gamma_t^g x_t^g\right)\right)v_{t+1}\right]\right\}, \tag{1.43}$$

$$\begin{aligned} v_t^g = {} & \pi_t^g - e_t x_t^T + \\ & \phi\mathbb{E}_t\left\{\Lambda_{N,t+1}\left[\lambda\left(\Gamma_t^T x_t^T\right)v_{t+1}^T + \left(1-\lambda\left(\Gamma_t^T x_t^T\right)\right)v_{t+1}^g\right]\right\}, \end{aligned} \tag{1.44}$$

$$v_t^T = \pi_t^T + \phi E_t\left\{\Lambda_{N,t+1}v_{t+1}^T\right\}, \tag{1.45}$$

where the optimal investments in exporting and transferring the production of intermediate goods from $N$ to $S$ are given by the optimality conditions

$$1 = \phi\Gamma_t^g\lambda'\left(\Gamma_t^g x_t^g\right)\mathbb{E}_t\left\{\Lambda_{N,t+1}\left(v_{t+1}^g - v_{t+1}\right)\right\}, \tag{1.46}$$

$$e_t = \phi\Gamma_t^T\lambda'\left(\Gamma_t^T x_t^T\right)\mathbb{E}_t\left\{\Lambda_{N,t+1}\left(v_{t+1}^T - v_{t+1}^g\right)\right\}. \tag{1.47}$$

The amount of output devoted to developing new technologies through R&D is determined by the following free entry condition:

$$S_t = \phi\mathbb{E}_t\left\{\Lambda_{N,t+1}v_{t+1}(A_{t+1} - \phi A_t)\right\}. \tag{1.48}$$

These investments in the development and diffusion of technology allow us

to characterize the evolution of technology in both countries.

*Evolution of Technology.*– The evolution of productivity over the medium and long term in $N$ and $S$ depends on the dynamics of innovation and international diffusion. New technologies are developed according to the following law of motion:

$$\frac{A_{Nt+1}}{A_{Nt}} = \chi \left( \frac{S_t}{\overline{P}^k_{Nt} K_{Nt}} \right)^{\rho} + \phi. \tag{1.49}$$

The optimal diffusion and adoption conditions together with the laws of motion for $A^g$, and $A^T$ yield the following equilibrium dynamics for the stock of global and transferred intermediate goods:

$$\frac{A^g_{t+1}}{A^g_t} = \phi\lambda(\Gamma^g_t x^g_t)\frac{A^l_t}{A^g_t} + \phi(1 - \lambda(\Gamma^T_t x^T_t)); \tag{1.50}$$

$$\frac{A^T_{t+1}}{A^T_t} = \phi\lambda(\Gamma^T_t x^T_t)\frac{A^g_t}{A^T_t} + \phi. \tag{1.51}$$

Finally, the definition of $A_{Nt}$ allows us to determine the stock of local intermediate goods, $A^l_t$.

$$A^l_t = A_{Nt} - A^g_t - A^T_t.$$

*Relative Price of Capital.*– The price of new capital is equal to a markup times the marginal cost of production.

$$P^K_{Nt} = \mu^K \theta N^{-(\mu_{kN}-1)}_{kNt} (a_{Nt} A^l_t)^{-(\theta-1)}; \tag{1.52}$$

$$P^K_{St} = \mu^K \theta \frac{(N_{kSt})^{-(\mu_{kS}-1)}}{\xi} (a_{St} A^T_t)^{-(\theta-1)}. \tag{1.53}$$

Observe from (1.52) and (1.53) that the efficiency gains associated with $A_{ct}$

and $N_{ct}^k$ reduce the marginal cost of producing investment. Fluctuations in these variables are responsible for the evolution in the short, medium and long run of the price of new capital, $P_{ct}^K$. However, $A_{ct}$ and $N_{ct}^k$ affect $P_{ct}^K$ at different frequencies.

Because $A_{ct}$ is a state variable, it does not fluctuate in the short term. Increases in $A_{ct}$ reflect embodied technological change and drive the long-run trend in the relative price of capital. Pro-cyclical investments in the development and diffusion of new intermediate goods lead to pro-cyclical fluctuations in the growth rate of $A_{ct}$, generating counter-cyclical movements in $P_{ct}^K$ over the medium term. $N_{ct}^k$, instead, is a stationary jump variable. Therefore, the entry/exit dynamics drive only the short term fluctuations in $P_{ct}^K$.

In light of the frequency at which these mechanisms operate, we can decompose $P_{ct}^K$ into the product of two terms: the medium term wholesale price, $\overline{P}_{ct}^K$, defined in (1.54), that is governed exclusively by technological conditions in the medium term, and a high-frequency component, $P_{ct}^K/\bar{P}_{ct}^K$, that is instead governed by cyclical factors:

$$\bar{P}_{ct}^K = (A_{ct})^{-(\theta-1)}. \tag{1.54}$$

*Balance of Payments.–* The current account balance is equal to the trade balance plus the net income from FDI investments. In equilibrium, a current account deficit needs to be financed by an identical net inflow of capital. Since the only form of capital that flows internationally is foreign direct investment,

the financial account balance is equal to the net inflow of FDI:

$$\overbrace{\underbrace{\frac{Q_{Nt}J_{Nt}A_t^T}{\mu_{kNt}a_{Nt}A_t^l}\left(\frac{\psi\xi}{e_t}\right)^{\frac{1}{\theta-1}} - \frac{e_tQ_{St}J_{St}A_t^g}{\mu_{kSt}a_{St}A_{St}^T}\left(\frac{\psi e_t}{\xi}\right)^{\frac{1}{\theta-1}}}_{S's \text{ Trade balance}} \underbrace{-\pi_t^T A_t^T}_{S's \text{ Net income}}}^{\text{Current account balance in } S} = -\overbrace{e_t x_t^T A_t^g}^{S's \text{ financial account balance}} . \tag{1.55}$$

# 1.5 Model Evaluation

In this section we explore the ability of the model to generate cycles at short and medium term frequencies that resemble those observed in the data in developed and, especially, in developing economies. Given our interest in medium term fluctuations, a period in the model is set to a year. We solve the model by loglinearizing around the deterministic balanced growth path and then employing the Anderson-Moore code, which provides numerical solutions for general first order systems of difference equations.[17] We describe the calibration before turning to some numerical exercises.

## 1.5.1 Calibration

The calibration we present here is meant as a benchmark. We have found that our results are robust to reasonable variations around this benchmark. To the greatest extent possible, we use the restrictions of balanced growth to pin down parameter values. Otherwise, we look for evidence elsewhere in the literature. There are a total of twenty-seven parameters summarized in Table 2. Thirteen appear routinely in other studies. Six relate to the process of innovation and R&D and were used, among others, in Comin and Gertler (2006). Finally, there are eight new parameters that relate to trade and the

[17] Anderson and Moore (1983).

process of international diffusion of intermediate goods and two related to the adjustment costs. We defer the discussion of the calibration of the standard and R&D parameters to the Appendix and focus here on the adjustment costs parameters and those that govern the interactions between $N$ and $S$.

We treat asymmetrically adjustment costs in Mexico and the U.S. based on the ample evidence on the thinner secondary markets for capital goods, more prevalent irreversibilities in plant-level investment, and larger costs of obtaining construction permits and import licenses in Mexico relative to the U.S. (e.g. Gelos and Isgut, 2001, Gwartney et al., 2007, World Bank, and Miller and Holmes, 2009). Comin et al. (2009) estimate $\xi''_N(1)$ structurally using a similar model with just one country (i.e. the U.S.) and with an endogenous counter-cyclical relative price of capital as in our model. They obtain an estimate close to 1 that is not statistically different from 1. Accordingly, we set $\xi''_N(1)$ to 1.

It is more intricate to calibrate $\xi''_S(1)$ since, to the best of our knowledge, there are no estimates of investment flow adjustment costs models for developing countries. However, it is possible to use the existing estimates of quadratic adjustment costs for developing countries to obtain a reasonable calibration for $\xi''_S(1)$. As discussed above, investment adjustment costs introduce a wedge between the price of installed ($P^I_t$) and uninstalled capital ($P^K_t$). A natural way to calibrate $\xi''_S(1)$ is to set it to a value that allows our model to match the elasticity of the wedge between $P^I_{St}$ and $P^K_{St}$ with respect to investment. One difference between models with quadratic and with investment flow adjustment costs is that in the former the wedge between $P^I_{St}$ and $P^K_{St}$ depends only on current investment while in the latter it also depends on future investment (i.e. $J_{St+1}$). Therefore, a natural way to calibrate $\xi''_S(1)$ is to set it to match the elasticity of the price wedge to a 1% permanent increase in

investment.[18] Using the estimates from Iscan (2000), and Warner (1992 and 1994), this exercise yields a value for $\xi''_S(1)$ of 1.5.

We calibrate the six parameters that govern the interactions between $N$ and $S$ by matching information on trade flows, and U.S. FDI in Mexico, the micro evidence on the cost of exporting and the relative productivity of U.S. and Mexico in manufacturing. First, we set $\xi$ to 2 to match Mexico's relative cost advantage over the U.S. in manufacturing identified by Iyer (2005). We set the inverse of the iceberg transport cost parameter, $\psi$, to 0.95,[19] the steady state probability of exporting an intermediate good, $\lambda^g$, to 0.0875, and the steady state probability of transferring the production of an intermediate good to $S$, $\lambda^T$, to 0.0055. This approximately matches the share of Mexican exports and imports to and from the U.S. in Mexico's GDP (i.e. 18% and 14%, respectively) and the share of intermediate goods produced in the U.S. that are exported to Mexico. Specifically, Bernard, Jensen, Redding and Schott (2007) estimate that approximately 20 percent of U.S. durable manufacturing plants export. However, these plants produce a much larger share of products than non-exporters. As a result, the share of intermediate goods exported should also be significantly larger. We target a value of 33% for the share of intermediate goods produced in the U.S. that are exported. This yields an average diffusion lag to Mexico of 11 years, which seems reasonable given the evidence (e.g. Comin and Hobijn, 2010).

Das, Roberts and Tybout (2007) have estimated that the sunk cost of exporting for Colombian manufacturing plants represents between 20 and 40 percent of their annual revenues from exporting. We set the elasticity of $\lambda^g$

[18] In practice, the calibrated value would be the same whether the increment is permanent or only lasts for two periods.

[19] Interestingly, the value of $\psi$ required to match the trade flows between the US and Mexico is smaller than the values used in the literature (e.g. 1/1.2 in Corsetti et al., 2008) because of the closeness of Mexico and the US and their lower (nonexistent after 1994) trade barriers.

with respect to investments in exporting, $\rho_g$, to 0.8 so that the sunk cost of exporting represents approximately 30 percent of the revenues from exporting. The elasticity of $\lambda^T$ with respect to FDI expenses, $\rho_T$, together with the steady state value of $\lambda^T$, determine the share of U.S. FDI in Mexico in steady state. We set $\rho_T$ to 0.5 so that U.S. FDI in Mexico represents approximately 2% of Mexican GDP.

### 1.5.2 Impulse response functions

To be clear, the exercises that follow are meant simply as a first pass at exploring whether the mechanisms we emphasize have potential for explaining the data: They are not formal statistical tests. For simplicity, the only two shocks we consider are innovations to the wage markup, $\mu_{ct}^w$, in $N$ (U.S.) and in $S$ (Mexico). Several authors[20] have argued that these shocks may capture important drivers of business cycles. However, we show that our findings are robust to other relevant shocks such as shocks to TFP and to the relative price of capital.

*Response to a U.S. Shock.*– Figure 2 displays the impulse response functions to a U.S. wage markup shock. Solid lines are used for the responses in Mexico while dashed lines represent the responses in the U.S. The response of the U.S. economy to a domestic shock is very similar to the single-country version presented in Comin and Gertler (2006). In particular, a positive wage markup shock contracts domestic labor supply (panel 2) causing a recession (panel 1). In addition to the decline in hours worked, the initial decline in U.S. output is driven by exit in the final goods sector and by a decline in the utilization rate. The response of U.S. output to the shock is more persistent than the shock itself (panel 12) due to the endogenous propagation mechanisms of the model. In

[20]E.g. Hall (1997), Gali, Gertler and Lopez-Salido (2002).

particular, the domestic recession reduces the demand for intermediate goods and, hence, the return to R&D investments. This leads to a temporary decline in the rate of development of new technologies but to a permanent effect on the level of new technologies relative to trend. The long run effect of the shock on output is approximately 50% of its initial response.[21]

The U.S. shock has important effects on Mexico's economy. Upon impact, the decline in Mexico's output is as large as the decline in U.S. output. Mexico's recession is driven by two forces: the decline in the demand for Mexican exports to the U.S. (panel 10) and the collapse of Mexico's investment (panel 4).

Unlike the U.S., the response of Mexico's output to a U.S. shock is hump-shaped. At the root of this response we find the dynamics of international technology diffusion. In particular, the shock to $\mu^w_{Nt}$ reduces the return on exporting new intermediate goods and transferring their production to Mexico. As a result, fewer resources are devoted to these investments (panel 7) gradually reducing the stock of intermediate goods in Mexico relative to the steady state (panel 8). Since productivity is determined by the stock of intermediate goods, the slow international diffusion of new technologies also leads to a gradual decline in Mexican productivity which causes the hump-shaped response of output.[22]

Our model generates large fluctuations in Mexico's productivity. This is at the root of why U.S. shocks have larger effects on Mexico's output than in

[21] In this version of the model, U.S. consumption responds more than U.S. output to a U.S. shock. As shown in Comin and Santacreu (2010), this is a consequence of the simplifying assumption that new technologies diffuse immediately in the U.S. When that is the case, U.S. shocks have large effects on U.S. permament income leading to large fluctuations in consumption. The introduction of a slow diffusion process as in Comin and Gertler (2006) or Comin and Santacreu (2010) fixes this counter-factual implication. The excess volatility of U.S. consumption does not affect significantly the business cycle dynamics in Mexico.

[22] In the US the response to the shock is monotonic because of the larger effect of the shock on domestic demand and because technology diffuses faster domestically than internationally.

the U.S. itself. Intuitively, the slow pace of international diffusion of intermediate goods generates a large gap between the stock of technologies available for production in the U.S. and Mexico. As a result, when a shock affects the return to exporting new technologies to Mexico, it induces very wide fluctuations in the flow of new technologies exported to Mexico resulting in wide swings, over the medium term, in the stock of technologies in Mexico. In the U.S., in contrast, there is no such a large stock of technologies waiting to be adopted. Thus, the fluctuations in the stock of technologies and productivity are significantly smaller than in Mexico.

To illustrate further the role of the international diffusion of technologies in Mexico's output dynamics, Figure 3 plots the impulse response function to a shock to $\mu_{Nt}^{w}$ after shutting down the extensive margin of trade and FDI channels. When eliminating these linkages between the U.S. and Mexico, the effect of the shock on Mexico's economy is much smaller. Mexico's GDP now declines by about one fifth of the decline in the model with endogenous technology diffusion. Further, the response of Mexico's output diminishes monotonically and it is less persistent than the response of U.S. output.

In contrast, in our model, the response of Mexico's output to a U.S. shock is more persistent than the U.S. response and much more persistent than the shock itself. Thus, endogenous international technology diffusion can provide a microfoundation for the finding of Aguiar and Gopinath (2007) that (in a reduced form specification) the shocks faced by developing countries are more persistent than those faced by developed economies.

The gradual decline in $A_{St}$ slowly reduces the efficiency of production of new capital leading to a gradual increase in the price of capital (panel 6). The initial response of Mexico's investment to these prospects for the price of capital largely depends on the magnitude of the adjustment costs. Figure 4

reports the impulse response functions to a contractionary $\mu^w_{Nt}$ shock with no adjustment costs. In the absence of adjustment costs, firms want to time the decline in investment with the peak in the price of new capital. As a result investment does not decline initially but declines sharply later on.

In the presence of adjustment costs, it is very costly to follow this strategy and companies start reducing their investment when the shock hits the economy in anticipation of the future increase in the price of capital. As a result, a contractionary U.S. shock generates a collapse of Mexico's investment upon impact (panel 4 of Figure 2) which continues to decline as the price of capital increases and the economy contracts further. As we shall show below, the data supports the model's prediction of a strong co-movement between U.S. output and Mexico's investment.

The response of investment to U.S. shocks significantly amplifies the initial response of Mexico's output to the U.S. shock. (See Figures 2 and 4.) In the absence of adjustment costs, Mexico's investment does not decline when the shock hits the economy and the only force that drives Mexico's recession is the decline in demand for Mexican exports to the U.S. Since the share of exports in Mexican GDP is not that large, Mexico's output declines only by 0.025% in response to a 1% increase in $\mu^w_{Nt}$. With adjustment costs, the collapse of investment contributes to Mexico's recession and output declines by 0.45% in response to the same shock. However, note that in both cases the decline in Mexico's output eventually exceeds the size of the recession generated in the U.S. Similarly, the hump-shaped response of Mexico's output is independent of the calibration of the adjustment costs.

*Response to a Mexican Shock*– Figure 5 displays the impulse response functions to a Mexican wage markup shock ($\mu^w_{St}$) in the U.S. (dashed) and in Mexico (solid). There are some striking differences with Figure 2. First, a Mexican

shock has virtually no effect in the U.S. This follows from the difference in size between the two economies but also from the fact that technologies flow from the U.S. to Mexico and not otherwise. One consequence of this is that the Mexican shock has a smaller effect than the U.S. shock on the extensive margin of trade and FDI. As a result, the effect of $\mu^w_{St}$ on Mexico's GDP is more transitory than the effect of a U.S. shock.

However, the most significant observation from Figure 5 is that Mexican shocks have a larger effect on Mexico's consumption than on output. This is the result of both the endogenous relative price of capital and the adjustment costs. We explain next the intuition for this result.

By the logic explained above, a contractionary shock leads to a gradual increase in the price of capital. The prospect of a future higher price of capital has two effects. On the one hand, it prevents investment from falling too much initially. (This is also achieved by the adjustment costs. See the contrast with the impulse response to a Mexican shock in the model without adjustment costs in Figure A1.)[23] On the other, it raises current and future interest rates despite the lower marginal product of capital due to the recession. High current and future interest rates induce consumers to tilt their consumption profile against current consumption.

Such a significant decline in Mexico's consumption is feasible for two reasons. First, investment does not fall too much initially. Second, consistent with the data, the trade balance is very counter-cyclical. This, in turn, is a consequence of the persistent response of investment to the shock. Because the response of Mexico's investment is so persistent, the value of transferring the

[23]Adjustment costs smooth the initial response of Mexico's investment to the domestic shock. This has two effects. On the one hand, it absorbs resources forcing consumption to decline. On the other, it increases the persistence of the effects of the shocks, amplifying the decline in capital gains from exporting and conducting FDI to Mexico. As a result, the price of capital in Mexico fluctuates more generating a larger appreciation in Mexico's price of capital which leads to higher interest rates in response to the shock.

production of intermediate goods to Mexico, $v^T$, declines more than net income from transferred technologies, $\pi^T$ (panel 9). This leads to a significant decline in FDI inflows into Mexico, a phenomenon that has motivated the "sudden stops" literature (e.g. Calvo, 1998). To reestablish the international equilibrium, the peso depreciates, leading to a trade surplus that absorbs resources and forcing Mexico's consumption to fall.[24]

Note that one of the key drivers of the high volatility of consumption in Mexico is the counter-cyclicality of the price of capital. As we show below, this prediction is borne by the data. The price of new capital in Mexico is very counter-cyclical at the high frequency with a correlation between HP-filtered output and HP-filtered price of capital of -0.55.[25] Interestingly, the price of new capital is significantly more counter-cyclical in Mexico than in the U.S., where the equivalent correlation is -0.08. This may explain why consumption is as volatile as GDP in Mexico but not in the U.S.

Comparing Figures 2 and 5, it is clear that the high relative volatility of consumption in Mexico is driven by Mexican shocks rather than by U.S. shocks. This is the case because Mexican shocks have a much larger effect on Mexico's interest rates than U.S. shocks. Intuitively, U.S. shocks trigger a more persistent decline in Mexico's output than Mexican shocks. As a result, Mexican companies want to cut their investment more drastically in response to them. This leads to a larger initial increase in the price of installed capital ($P_S^I$) which reduces the increase in the slope of $P_S^I$ due to the gradual increase

[24]The strong counter-cyclical current account is documented by Neumeyer and Perri (2005) in a sample of developing countries (which includes Mexico).

[25]The counter-cyclicality of the price of new capital in Mexico is robust to other filtering methods. For example, the correlation between the growth rate in the price of capital and HP-filtered output is -0.65. Over the medium term cycle the correlation between Mexico's price of capital and GDP is -0.71. In the U.S., the correlation between these variables over the medium term is -0.55. For the full post-war period, the correlations in the U.S. are slightly larger (in absolute value): -0.18 for HP-filtered data and -0.66 over the medium term.

in the price of new capital ($P_S^K$).[26] Hence the lower increase in interest rates following a recessionary shock in the U.S. than one in Mexico.

### 1.5.3 Simulations

We next turn to the quantitative evaluation of the model. To this end, we calibrate the volatility and persistence of wage markups shocks in the U.S. and Mexico and run 1000 simulations over a 17-year long horizon each. Since we intend to evaluate the model's ability to propagate shocks both internationally and over time, we use the same autocorrelation for both U.S. and Mexican shocks and set the cross-country correlation of the shocks to zero. We set the annual autocorrelation of markup shocks to 0.6 to match the persistence of markups in the U.S.[27]

We calibrate the volatility of the shocks by forcing the model to approximately match the high frequency standard deviation of GDP in Mexico and the U.S. This yields a volatility of the wage markup shock of 3.53% in the U.S. and 4.59% in Mexico. This is consistent with the suspicion that developing economies are prone to bigger disturbances than developed countries.

*Volatility*.– Table 3 compares the standard deviations of the high frequency and medium term cycle fluctuations in the data and in the model. Our calibration strategy forces the model to match the volatilities of output in Mexico and the U.S. at the high frequency. In addition, the model also comes very close to matching the volatility of output over the medium term both in Mexico (0.04 vs. 0.037 in the data) and in the U.S. (0.026 vs. 0.015 in the data).

[26] As discussed above, a decline in investment leads to an increase in the price of installed capital because the adjustment costs embedded in (1.23) imply that lower levels of investment today increase the costs of investment tomorrow.

[27] See Comin and Gertler (2006) for details. Note that, because of the propagation obtained from the endogenous technology mechanisms, this class of models requires a smaller autocorrelation of the shocks to match the persistence in macro variables. In short, they are not affected by the Cogley and Nason (1995) criticism that the Neoclassical growth model does not propagate exogenous disturbances.

Given the low persistence of shocks, matching these moments suggests that the model induces the right amount of propagation of high frequency shocks into the medium term.

The model does a good job in reproducing the volatility observed in the data in variables other than output. It does a remarkable job in matching the volatility of Mexico's consumption both at the high frequency (0.031 vs. 0.031 in the data) and over the medium term cycle (0.044 vs. 0.04 in the data). This is of special interest given the attention that the international macro literature has given to these moments.

The model also generates series for investment, the relative price of capital, bilateral trade flows, the extensive margin of trade and FDI flows that have similar volatilities to those observed in the data both at the high frequency and medium term. For those instances where there are some differences, the empirical volatilities tend to fall within the 95% confidence interval for the standard deviation of the simulated series.[28]

*Co-movement.*– Most international business cycle models have problems reproducing the cross-country co-movement patterns observed in macro variables. First, they lack international propagation mechanisms that induce a strong positive co-movement in output. Second, they tend to generate a stronger cross-country co-movement in consumption than in output, while in the data we observe the opposite (Backus, Kehoe and Kydland, 1992).[29]

Our model fares well in both of these dimensions. Panel A of Table 4

[28]One exception is the growth in the number of intermediate goods exported from the U.S. to Mexico, where our model generates less volatility than we observe in the data counterpart of this variable.

[29]Several authors, including Baxter and Crucini (1995) and Kollmann (1996), have shown that reducing the completeness of international financial markets is not sufficient to match the data along these dimensions. Kehoe and Perri (2002) have made significant progress by introducing enforcement contraints on financial contracts. This mechanism limits the amount of risk sharing, reducing consumption co-movement and increasing the cross-country co-movement in output. However, output still co-moves significantly less than in the data.

reports the cross country correlations between Mexico and the U.S. for consumption and output, both in the model and in the data. The model generates the strong co-movement between U.S. and Mexico GDPs observed in the data. The average cross-country correlation in our simulations is 0.68 with a confidence interval of (0.3 , 0.89) that contains the correlation observed in the data (0.43). The model also generates a smaller cross-country correlation for consumption than for output, as we observe in the data: The average cross-correlation is 0.055 with a confidence interval that contains the empirical correlation (0.2).[30]

Our model's ability to match the empirical cross-country co-movement patterns resides in the combination of endogenous diffusion and flow investment adjustment costs. The endogenous international diffusion of technologies generates a strong cross-country co-movement in output and productivity over the medium term. Because of adjustment costs, Mexican firms respond to the future productivity path by adjusting their investment contemporaneously in a pro-cyclical way. This induces the cross-country correlation in output and investment. The large effect that foreign shocks have on domestic investment limits the possibility for a large consumption response, hence inducing a higher cross-country correlation in output than in consumption.

Panel B of Table 4 reports the contemporaneous correlation between the HP-filtered Mexican variables and HP-filtered output in both Mexico and the U.S.[31] Broadly speaking, the model does a very good job in capturing the contemporaneous co-movement patterns within Mexico but also between Mexico and the U.S. The model generates the observed correlation between consump-

[30]The international business cycle literature has also found it difficult to generate positive cross-correlations in investment and employment (Baxter, 1995). As it is clear from Figure 2, our model delivers both.

[31]Note that we do not filter the growth rate of intermediate goods since this variable is already trend stationary.

tion and output in Mexico (0.61 vs. 0.78 in the data). Note also that, in both model and data, Mexico's consumption is insignificantly correlated with U.S. GDP. This indicates that U.S. shocks do not contribute to the high volatility of Mexico's consumption. This instead is the result of the response of Mexico's consumption to domestic shocks.

A key driver of the volatility of consumption is the dynamics of the price of capital induced by domestic shocks. It is reassuring that the model matches the negative co-movement between Mexico's output and the price of new capital (-0.36 vs. -0.54 in the data). Note also that the model generates an insignificant contemporaneous co-movement between the price of capital in Mexico and U.S. GDP, which is consistent with the evidence (-0.08 in model vs. 0.13 in data). As we show below, this is the case because U.S. shocks drive the price of new capital over the medium term but not so much contemporaneously.

Recall that the strong co-movement between U.S. output and Mexico's investment is the key driver of the large effect that U.S. shocks have on Mexico's GDP. The model also captures the strong co-movement between Mexican investment and output in both the U.S. (0.77 vs. 0.6 in the data) and Mexico (0.69 vs. 0.62 in the data).

Similarly, recall that the medium term productivity dynamics in Mexico result from the cyclicality of the flow of intermediate goods that diffuse to Mexico (i.e. the extensive margin of trade). The model matches quite closely the correlation between our data-counterpart for this variable and output in both the U.S. (0.42 vs. 0.28 in the data) and in Mexico (0.43 vs. 0.42 in the data).

The model also captures broadly the cyclicality of the bilateral trade flows. In particular, the model generates the strong counter-cyclicality of Mexico's trade balance. The correlation between Mexico's trade balance and GDP is

-0.96 vs. -0.83 in the data. This is the case because, both in the data and in our model, imports from the U.S. co-move more with Mexico's GDP than exports to the U.S. The model also captures the high correlation of bilateral trade flows with U.S. GDP.

A variable where the model underperforms is FDI. Though the model matches cyclicality of FDI in the data, the correlations with both U.S. and Mexico's GDP are too high. This may reflect the presence of a small but volatile component in actual FDI that does not respond to the U.S. or Mexican business cycle. This hypothesis seems to be supported by the fact that FDI is much more persistent in our model than in the data.[32] In any case, the counterfactually high cyclicality of FDI flows does not affect significantly the model's ability to generate co-movement between the U.S. and Mexico. That is the case because the key driver of Mexican productivity dynamics is the stock of intermediate goods available for production in Mexico. Whether available intermediate goods are produced in Mexico or the U.S. is much less relevant for Mexican productivity.

*Inter-frequency Co-movement.*– One of the motivations for our model was the observation that U.S. high frequency fluctuations lead medium term fluctuations in Mexico. The impulse response functions to U.S. shocks (see Figure 2) show that, qualitatively, the model is able to generate these persistent effects. Table 5 explores the quantitative power of the model to reproduce the inter-frequency co-movement patterns we observe in the data. The first row of Table 5 reports the empirical correlation between lagged HP-filtered U.S. output and the medium term component of Mexico's output. The second row reports the average of these statistics across 1000 simulations of the model.

The model roughly captures the contemporaneous correlation between high

[32]In particular, the annual autocorrelation of FDI/GDP in our model is 0.42 while in the data it is -0.35.

frequency fluctuations in U.S. output and medium term fluctuations in Mexico's output (0.37 in the model vs. 0.28 in the data). More importantly, the model generates a hump-shaped cross-correlogram between these two variables as we observed in the data. However, in the data the peak correlation occurs after two years (0.53), while in the model it occurs on average after one year (0.42).

A key prediction of our model is that the high frequency response of the extensive margin of trade to U.S. shocks generates counter-cyclical fluctuations in the relative price of capital in Mexico over the medium term. The fourth row in Table 5 presents the average correlation across our 1000 simulations between the medium term component of Mexico's relative price of capital and HP-filtered U.S. output at various lags. In both actual and simulated data, the contemporaneous correlation is insignificant. The correlation becomes more negative as we lag U.S. GDP in both cases. In the simulated data the peak (in absolute terms) is reached after two years (-0.38), while in the actual data it is reached after three years (-0.5).

Unlike U.S. shocks, Mexican shocks do not have a hump-shaped effect on Mexico's output over the medium term fluctuations. The correlation between HP-filtered and the medium term component of Mexico's output is positive and declines monotonically as we lag the series of HP-filtered output.[33] Our model is consistent with this co-movement pattern. (See rows 5 and 6 in Table 5.)

[33]In the working paper version, we make a similar point by estimating VARs with HP-filtered Mexico's GDP and the medium term component of several Mexican variables (including GDP).

## 1.6 Discussion

Next, we explore in more detail the implications of our model and compare it to existing models of trade and international business cycles.

*Other Shocks.*– For concreteness, we have used wage markup shocks as the sole source of fluctuations in our simulations. However, our findings are not driven by the nature of the shocks. To illustrate this, we introduce shocks to TFP and to the price of investment. Figure 6 presents the impulse response functions to a (negative) TFP shock (second row) and a (positive) shock to the price of investment (third row) both in the U.S. To facilitate the comparison, the impulse response function to the U.S. wage markup shock is presented in the first row of the figure.

Qualitatively, the impulse response functions to these shocks are very similar. In all of them there is a large effect upon the impact of the U.S. shock on Mexican output, though the initial response for the two new shocks is smaller in Mexico than in the U.S. All shocks generate a hump-shaped response of Mexico's output. And in all three cases, the U.S. shock eventually has a larger effect on Mexico than in the U.S. The economics of the response are the same as in the wage markup shock described above. All three shocks trigger a large and persistent slowdown in the flow of new technologies to Mexico and an initial decline in Mexico's investment larger than the initial decline in consumption. As the productivity of the capital goods sector deteriorates relative to trend, investment declines further generating the hump in the output response.

The response to Mexican shocks is also robust to the nature of the shocks (see Figure 7). For the three Mexican shocks, Mexico's consumption responds initially more than output and the response of investment is hump-shaped. The similarity of the impulse responses across the three types of shocks suggests that a richer calibration that allowed for a broader set of shocks would

capture as well as our simulations the cyclical properties of the Mexican economy and the co-movement patterns with the U.S.

*Sunk vs. Fixed Exporting Costs.*– Much of the theoretical international macro literature that has incorporated the extensive margin of trade has relied on extensions of the Melitz (2003) model. The Melitz model is a two country model with firms of heterogenous productivity and where firms have to incur in some costs to export. Unlike our model, most of the models that have used the Melitz framework to explore business cycle dynamics use fixed cost instead of sunk cost to adjust the range of intermediate goods available for production.

The empirical literature on firm dynamics and exports has found that there are large sunk costs of exporting new products (e.g. Roberts and Tybout, 1997; Das et al., 2007). However, the use of fixed costs could be defended on the grounds of their tractability if the model with fixed costs has propagation and amplification power similar to that of the model with sunk costs of exporting. To explore whether this is the case, we develop a version of our model where, to export intermediate goods, firms in $N$ now just need to incur a per period fixed cost. For consistency, we also make the investment in transferring production from $N$ to $S$ a fixed cost. Other than these two changes, this version of the model is identical to our original model. This model is basically a variation on the financial autarky model in Ghironi and Melitz (2005) with physical capital and without heterogeneity. We calibrate the fixed costs of exporting and FDI so that in steady state the trade flows are the same as in our original model.

Figure 8 plots the impulse response functions to a U.S. wage markup shock in the model with fixed costs. The differences with our original model are remarkable. In the model with fixed costs of exporting, a contractionary U.S. shock causes a much smaller decline in Mexico's output - only 30% of the

decline in U.S. output - than in our model.[34] This is the case because in the model with fixed cost of exporting, the flow of exported and transferred intermediate goods adjusts in response to fluctuations in current profits. In the model with sunk costs, the flow of technologies adjusts in response to fluctuations in the present discounted value of profits. Given the high persistence of profits, the present discounted value of profits fluctuates more and more persistently than current profits. As a result, the range of intermediate goods declines by more over the medium term, generating larger increases in the relative price of capital and larger declines in investment.

The larger drop in U.S. than in Mexico's investment reduces the relative demand for intermediate goods produced in Mexico. To reestablish the international equilibrium, the peso needs to depreciate. The depreciation of the peso, together with Mexico's recession, causes a large drop in FDI and in the number of intermediate goods produced in Mexico. This is similar to the mechanism used in Bergin et al. (2009) to explain the higher volatility of off-shored industries in Mexico than in the U.S. observed in the data.[35]

*Implications for Aggregate Volatility.*– It is clear from Figure 2 that U.S. shocks are a significant source of volatility in Mexico's GDP. But what share of Mexican fluctuations is due to U.S. shocks and what share is due to domestic shocks? Similarly, how much do Mexican shocks contribute to the volatility of U.S. GDP?

Table 6 answers these questions by reporting the share of output volatility in each country attributable to each kind of shock. The first two columns

[34]This magnitude is consistent with the findings in Ghironi and Melitz (2005).

[35]A different approach to modeling production sharing is followed by Burnstein, Kurz and Tesar (2008). Rather than using variation in the extensive margin, their model assumes a complementarity between domestic and foreign intermediate goods in U.S. production. By changing the importance of the sector where domestic and foreign intermediate goods are complementary, they can generate a significant increase in the correlation between U.S. and Mexican manufacturing output.

focus on the volatility of HP-filtered output while the next two focus on the volatility of output over the medium term cycle. Consistent with Figure 5, Mexican shocks account for a small fraction of U.S. fluctuations (3% at high frequency and 2% over the medium term cycle).

In contrast, U.S. shocks represent a very significant source of Mexican fluctuations. At the high frequency, 64% of Mexico's GDP volatility is driven by U.S. shocks, while over the medium term cycle, U.S. shocks induce 66% of the volatility in Mexico's GDP. This proves the importance of explicitly modelling the U.S. economy to study the business and medium term cycles of the Mexican economy.

## 1.7 Conclusions

In this paper, we have developed an asymmetric two-country model to study business cycle fluctuations in developing countries. The model introduces two key elements: (i) endogenous and slow diffusion of technologies from the developed to the developing country, and (ii) flow adjustment costs to investment. These mechanisms yield five predictions consistent with the business cycles of developing countries.

First, business cycle shocks to developed economies have large effects on developing economies. Second, these effects are persistent inducing fluctuations at frequencies lower than the conventional business cycle. Third, the cross-country correlation of output is higher than that of consumption. Fourth, interest rates are counter-cyclical in developing countries. Fifth, consumption is more volatile than output in developing countries. After calibrating the model to the Mexican economy, we have found that the model also does a good job quantitatively.

One of the key contributions of this paper is to extend the business cycle models of endogenous technology (e.g. Comin and Gertler, 2006) to two-country settings. There are several alternative configurations of the two countries that are worth pursuing. One natural variation is to model both countries as advanced economies that develop new technologies through R&D and adopt each other's technologies. This configuration would naturally capture the interactions between the U.S. and the EU, or the U.S. and Japan. A second variation could be to keep the asymmetry between the developed and developing countries but introduce low frequency transitions in the developing country to its balanced growth path. This configuration would be helpful to analyze the interdependence between the U.S. and China at the high and medium term frequencies.

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# 1.A Chaper 1 Appendix: Calibration

In this appendix we describe the calibration of the twelve standard parameters and the six parameters that relate to the R&D process. We set the discount factor $\beta$ equal to 0.95, to match the steady state share of non-residential investment to output. Based on steady state evidence we also choose the following numbers: (the capital share) $\alpha = 0.33$; (government consumption to output) $G_N/Y_N = 0.2$ and $G_S/Y_S = 0.1$; (the depreciation rate) $\delta = 0.1$; and (the steady state utilization rate) $U = 0.8$, based on the average capacity utilization level in the postwar period as measured by the Board of Governors. We set the inverse of the Frisch elasticity of labor supply $\zeta$ at unity, which represents an intermediate value for the range of estimates across the micro and macro literature. Similarly, we set the elasticity of the change in the depreciation rate with respect to the utilization rate, $(\delta''/\delta')U$, at 0.15, used, for example, in Jaimovich and Rebelo (2009) and Comin, Gertler and Santacreu (2009). Finally, based on evidence in Basu and Fernald (1997), we fix the steady state gross value added markup in the consumption goods sector, $\mu_c$, equal to 1.1 and the corresponding markup for the capital goods sector, $\mu_k$, at 1.15. We normalize the number of final goods firms to 1. Given this normalization and the markups, we set the operating costs parameters, $b_c$ and $b_c^k$, so that the total overhead costs from entering are 10% of gross output. This implies that $b_c = 0.5$ and $b_c^k = 0.016$.

We set the population of the U.S. relative to Mexico to 3. Similarly, we set the relative productivity levels in final goods production to 3.35 so that U.S. GDP is approximately 12 times Mexico's GDP.

We next turn to the "non-standard" parameters. The estimates for the obsolescence rate have a range from the 4% per year in Caballero and Jaffe (1992) to around 20% in Pakes and Schankerman (1984). Based on this range

we consider an obsolescence rate of 10% which implies a value for $\phi$ of 0.9. The steady state growth rates of GDP and the relative price of capital in the model are functions of the growth rate of new technologies, which in our model are used to produce new capital, and of the exogenous growth rate of disembodied productivity, $g$. By using the balanced growth restrictions and matching the average growth rate of non-farm business output per working age person (0.024) and the average growth rate of the Gordon quality adjusted price of capital relative to the BEA price of consumption goods and services (-0.026), we can identify the growth rate of disembodied productivity, $g$, and the productivity parameters in the technologies for creating new intermediate goods, $\chi$. Accordingly, we set $g = 0.0072$ and $\chi = 2.69$.

There is no direct evidence on the gross markup $\theta$ for specialized intermediate goods. Given the specialized nature of these products, it seems that an appropriate number would be at the high range of the estimates of markups in the literature for other types of goods. Accordingly we choose a value of 1.5, but emphasize that our results are robust to reasonable variations around this number.

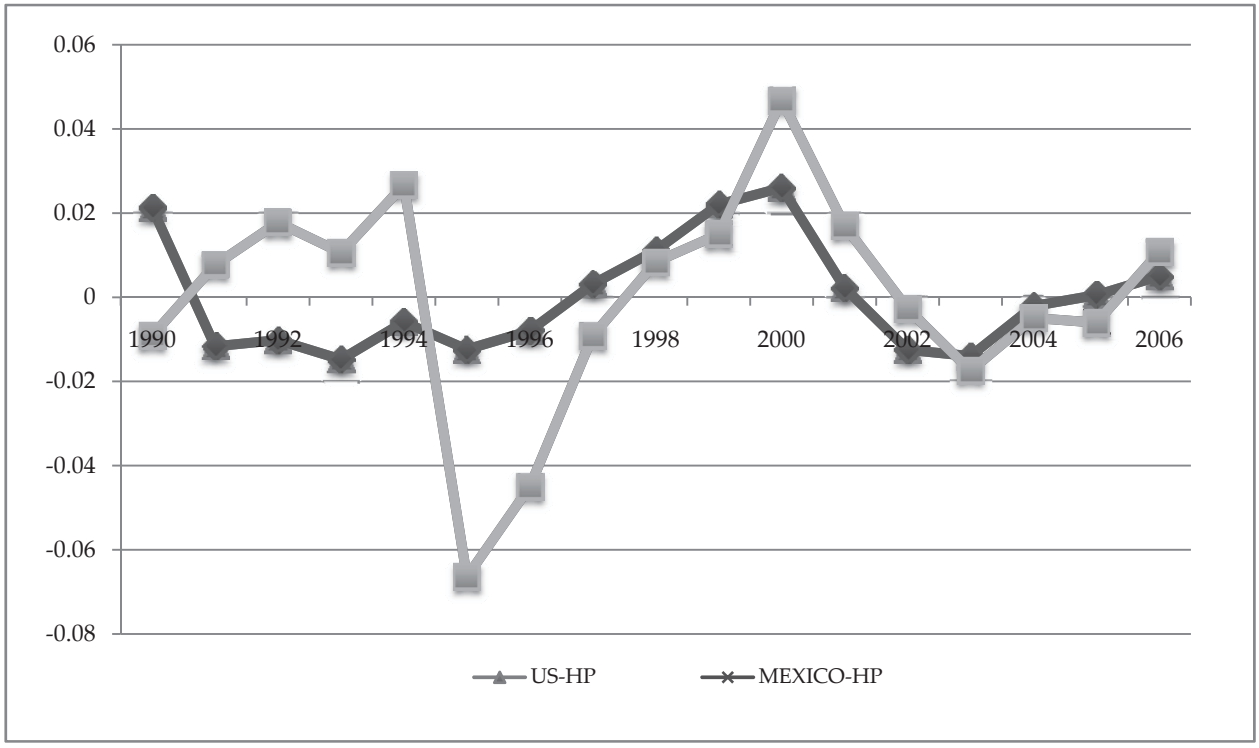
There is also no simple way to identify the elasticity of new intermediate goods with respect to R&D, $\rho$. Griliches (1990) presents some estimates using the number of new patents as a proxy for technological change. The estimates are noisy and range from about 0.6 to 1.0, depending on the use of panel versus cross-sectional data. We opt for a conservative value of 0.65, in the lower range. The calibrations of $\theta$, $\phi$, $\chi$ and $\rho$ yield an R&D share in U.S. GDP of approximately 1% which is in line with the ratio of private R&D expenditures in the investment goods sector to GDP, averaged over the period 1960-2006.

Finally, we fix the autocorrelation of the preference/wage markup shock to

0.6 so that the model generates an autocorrelation that approximately matches that of the total markup as measured by Gali, Gertler and Lopez Salido (2002). We set the autocorrelation of the TFP and price of investment shocks to 0.9.

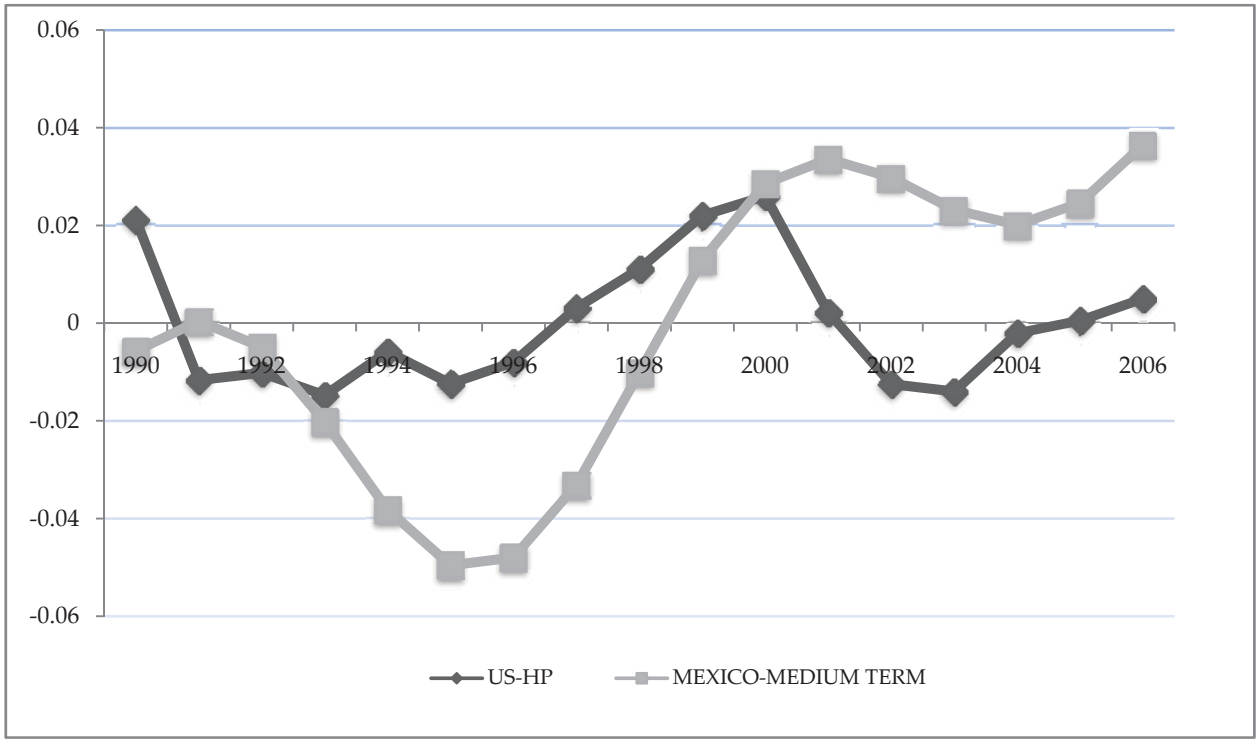
## 1.B Chapter 1 Figures & Tables

**Figure 1A: Evolution of HP-filtered GDP per working age population in Mexico and the US**



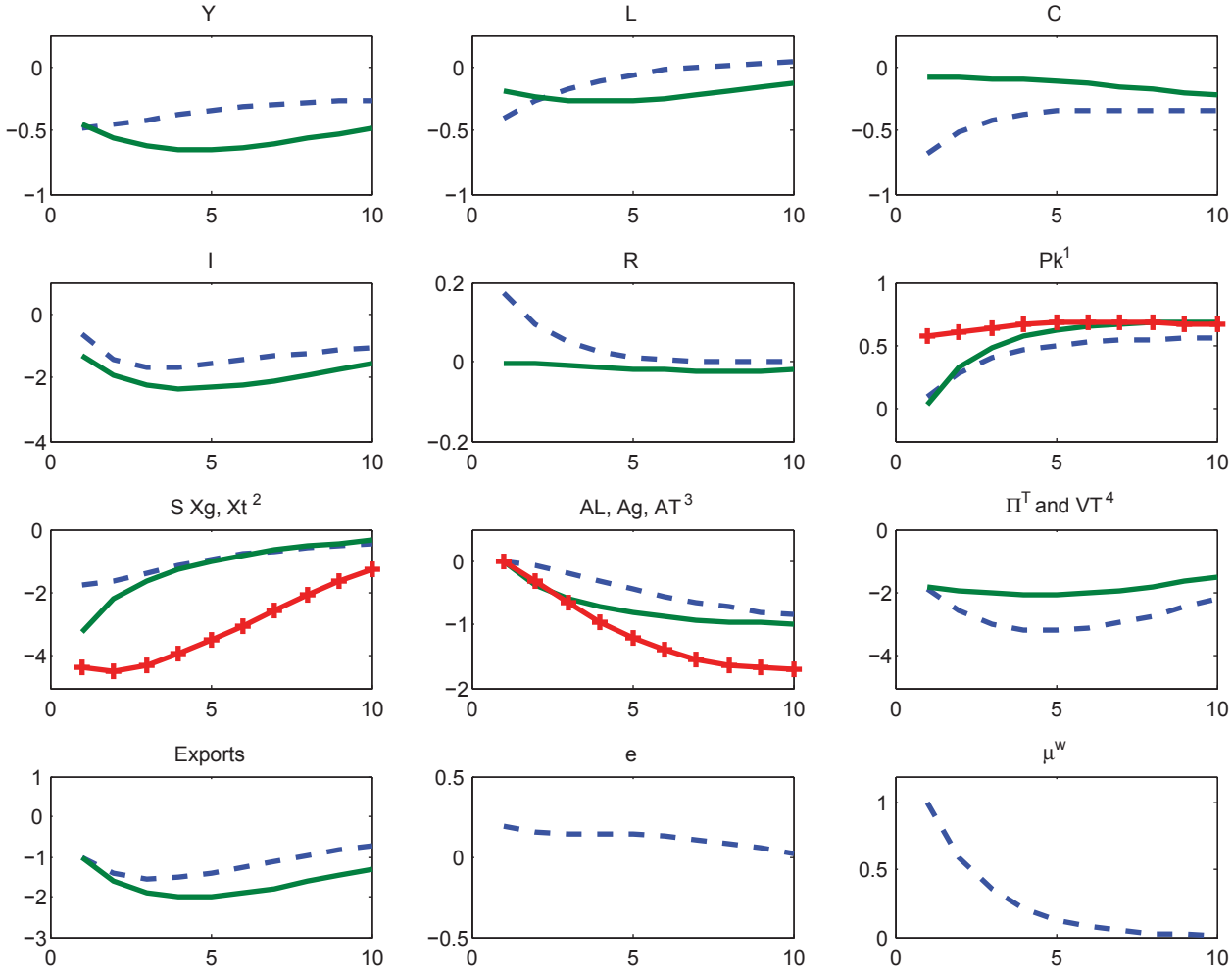

Source: World Development Indicators, Authors' calculations

**Figure 1B: Evolution of GDP per working age population in Mexico and the US filtered at different frequencies**



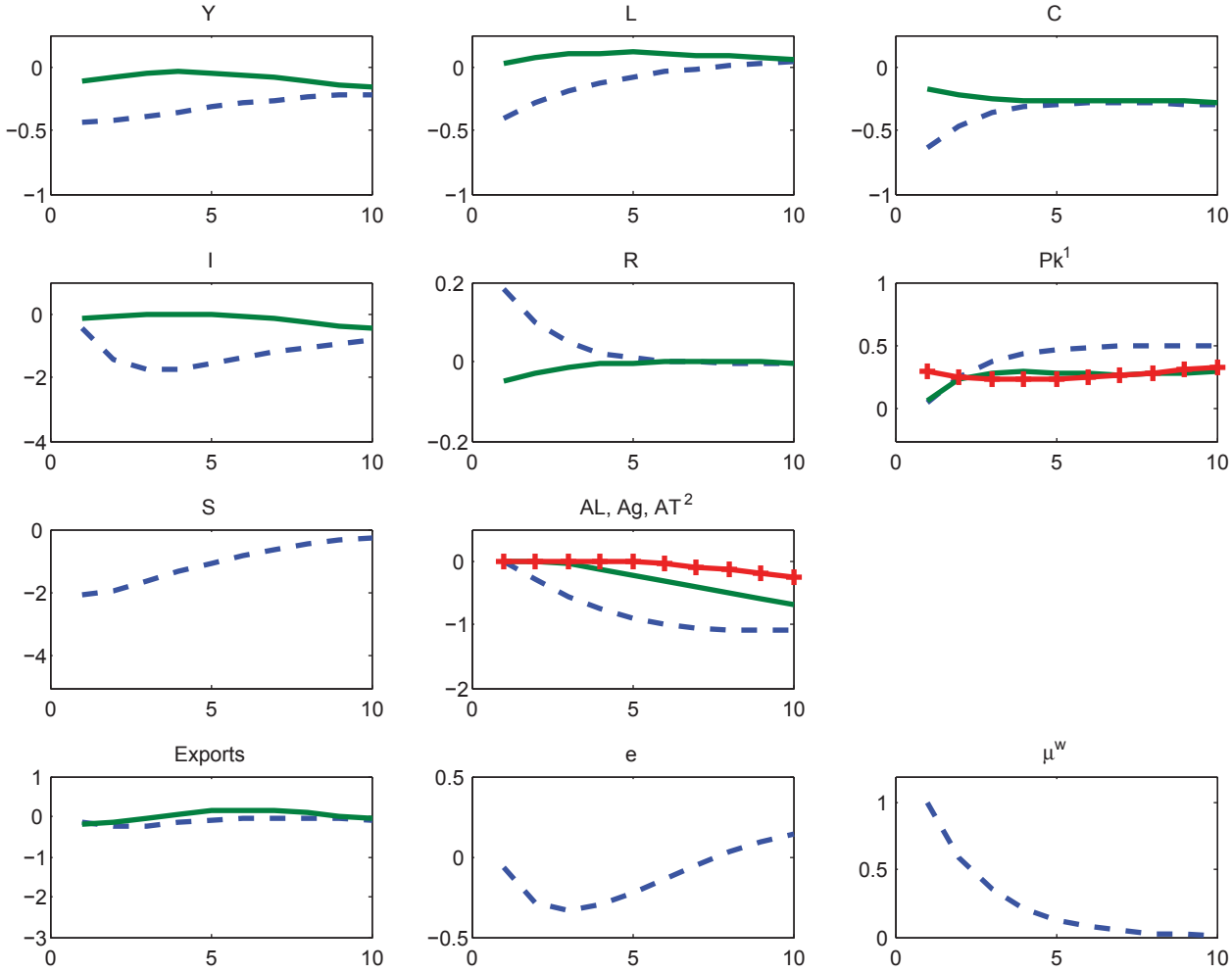

Source: World Development Indicators, Authors' calculations

Figure 2: Impulse Response Functions for U.S.Wage Markup Shock, Baseline Model (U.S. dash, Mexico, solid)




[1] Price of installed capital in Mexico (+)
[2] Research and development expenditures (S, --), investments in exporting (Xg,-) and FDI (Xt, -+)
[3] Local Intermediate Goods (AL,--), Exported Intermediate Goods(Ag,-) and Transfered Intermediate Goods(AT,-+)
[4] Net income from transferred intermediate goods (--), Value of transferred intermediate goods (-)

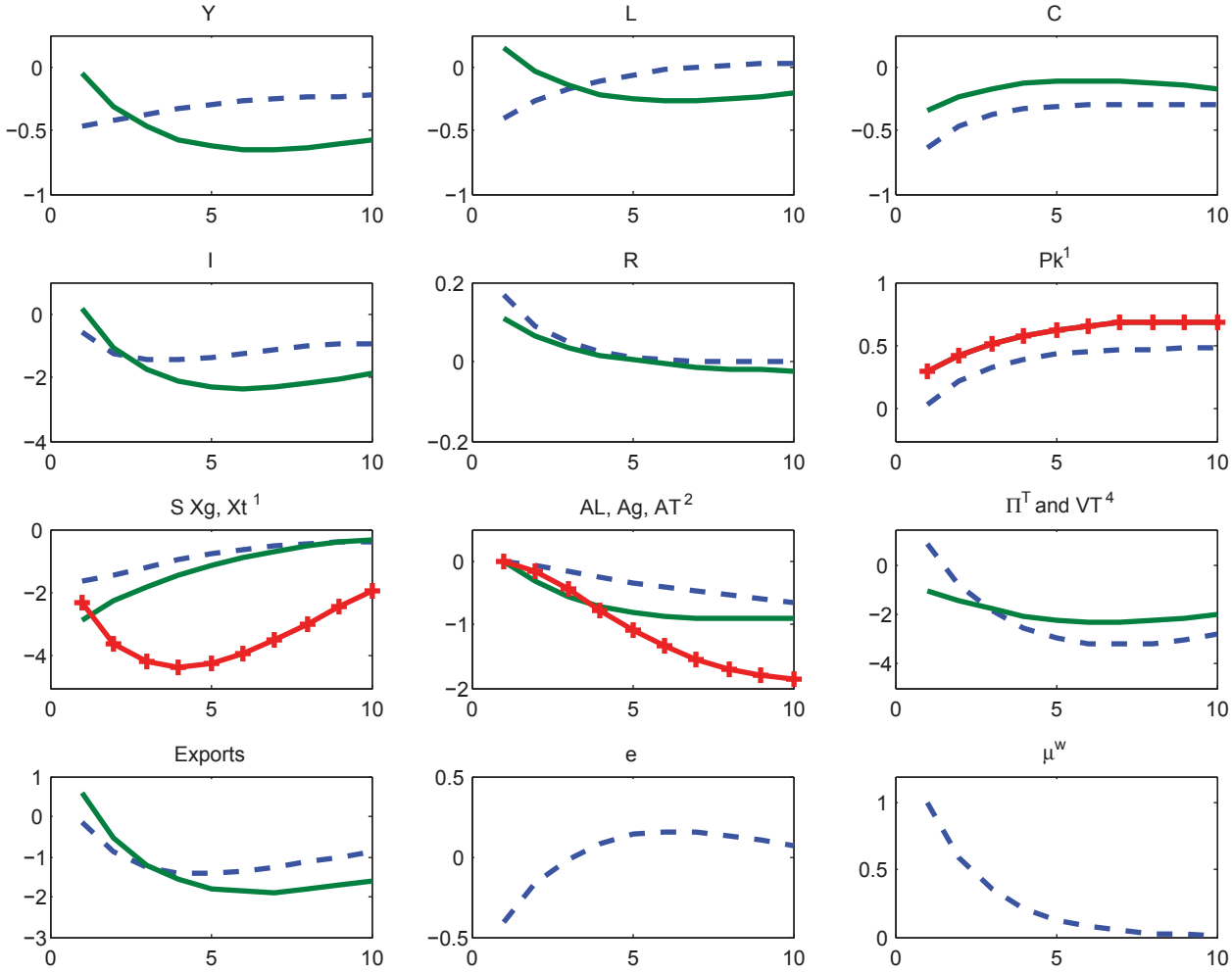
Figure 3: Impulse Response Functions for U.S. Wage Markup Shock, Model Without International Technology Flows (U.S.Dash, Mexico, solid)




[1] Price of installed capital in Mexico (+)

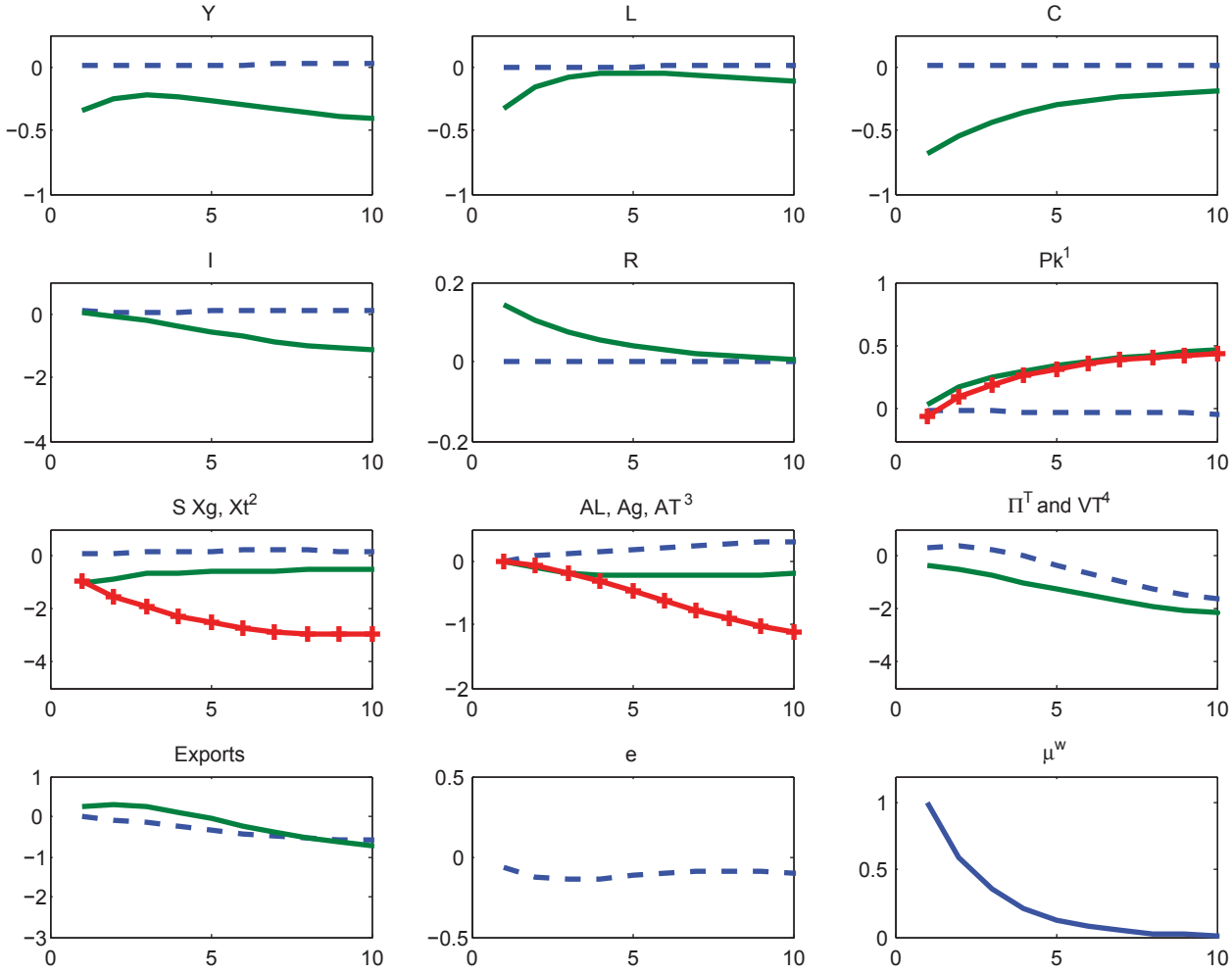
[2] Local Intermediate Goods (AL,--), Exported Intermediate Goods(Ag,-) and Transfered Intermediate Goods(AT,-+)

Figure 4: Impulse Response Functions for U.S. Wage Markup Shock, Model Without Adjustment Costs (U.S. Dash, Mexico, solid)



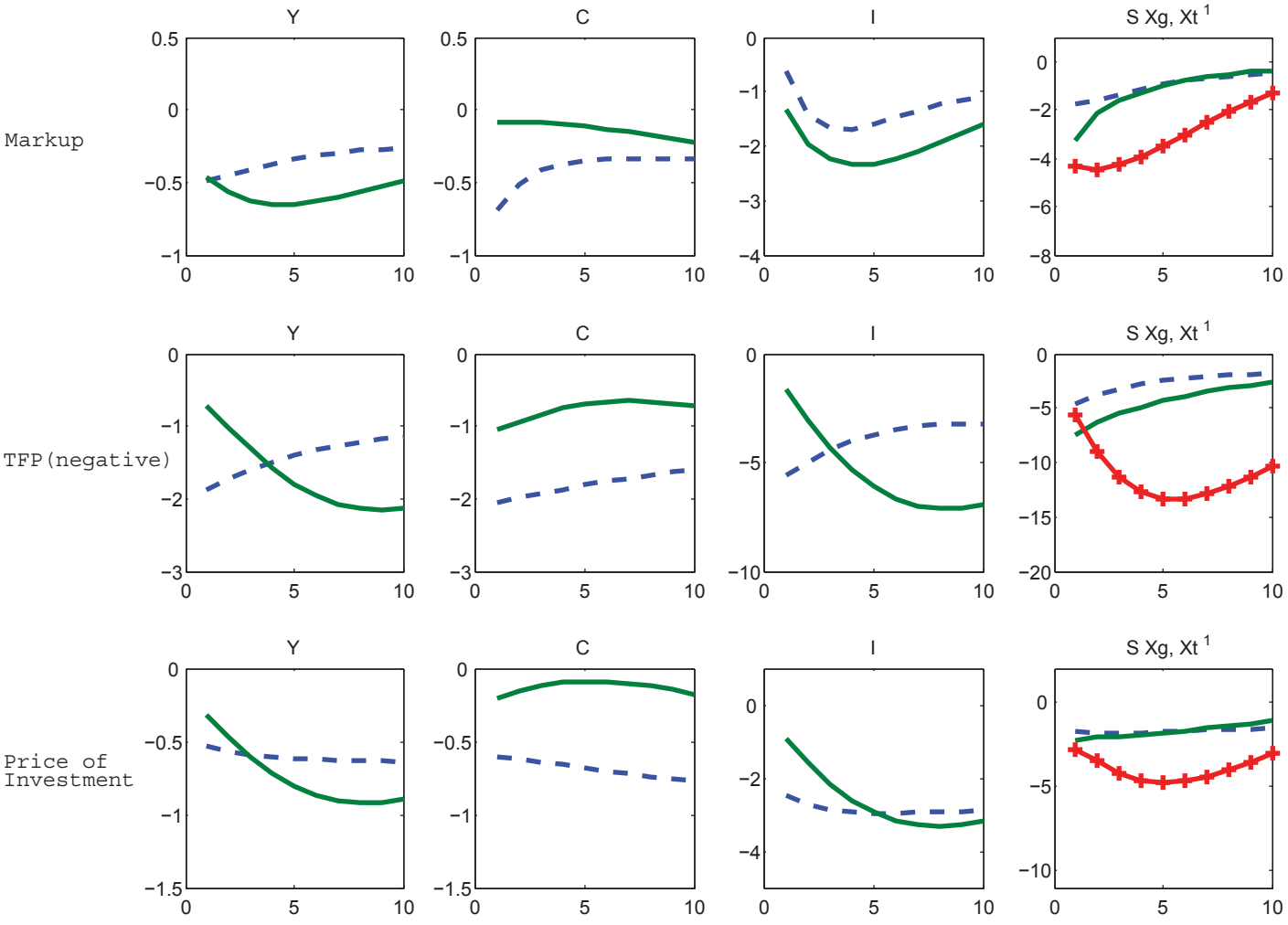

[1] Price of installed capital in Mexico (+)
[2] Research and development expenditures (S, --), investments in exporting (Xg,-) and FDI (Xt, -+)
[3] Local Intermediate Goods (AL,--), Exported Intermediate Goods(Ag,-) and Transfered Intermediate Goods(AT,-+)
[4] Net income from transferred intermediate goods (--), Value of transferred intermediate goods (-)

Figure 5: Impulse Response Functions for Mexico Wage Markup Shock, Baseline Model (U.S. dash, Mexico, solid)



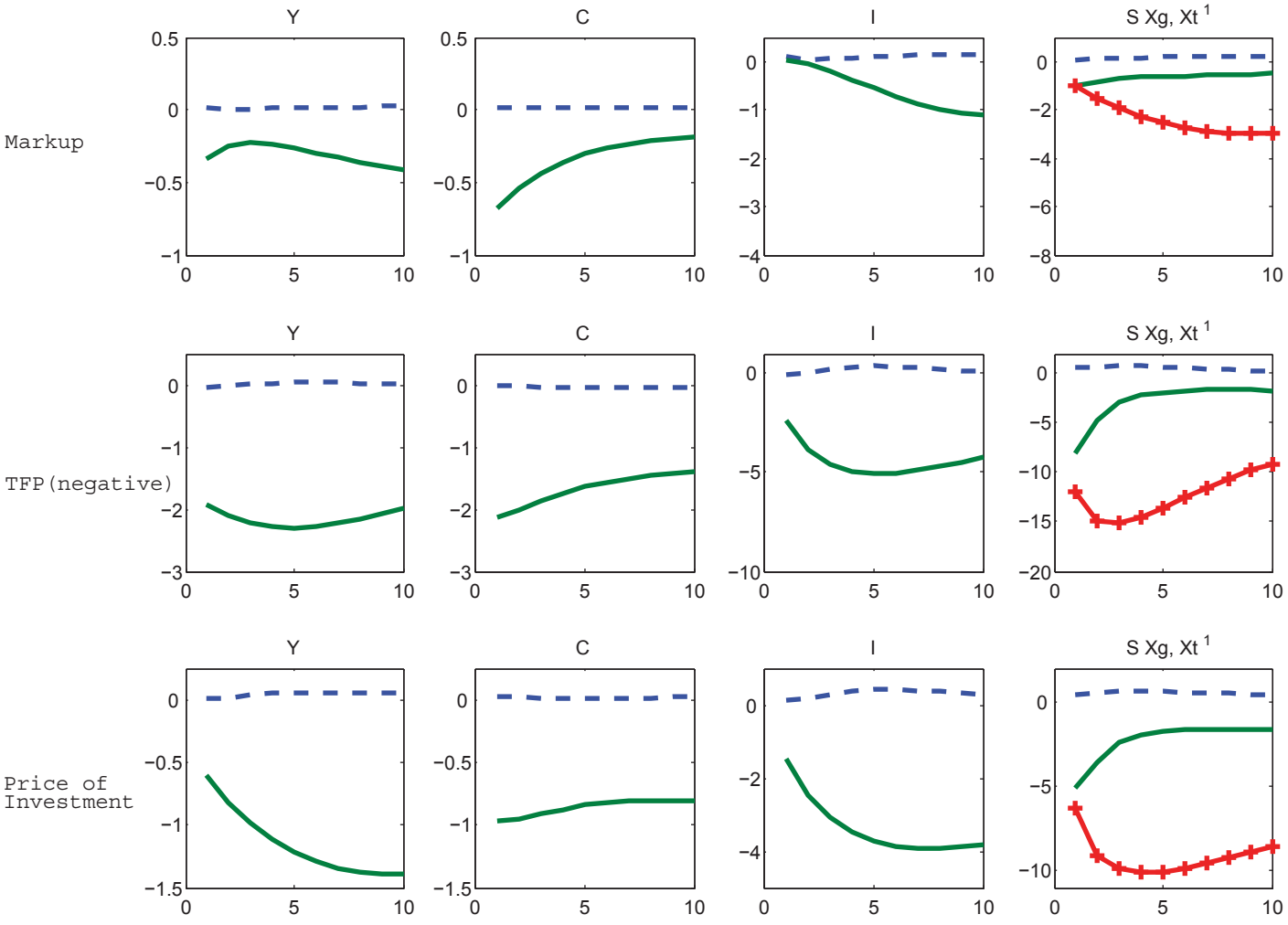

[1] Price of installed capital in Mexico (+)
[2] Research and development expenditures (S, --), investments in exporting (Xg,-) and FDI (Xt, -+)
[3] Local Intermediate Goods (AL,--), Exported Intermediate Goods(Ag,-) and Transfered Intermediate Goods(AT,-+)
[4] Net income from transferred intermediate goods ($\Pi^T$, --), Value of transferred intermediate goods (VT,-)

Figure 6: Impulse Response Functions for U.S. Wage Markup,TFP and Price of Investment Shocks
Baseline Model (U.S. dash, Mexico, solid)



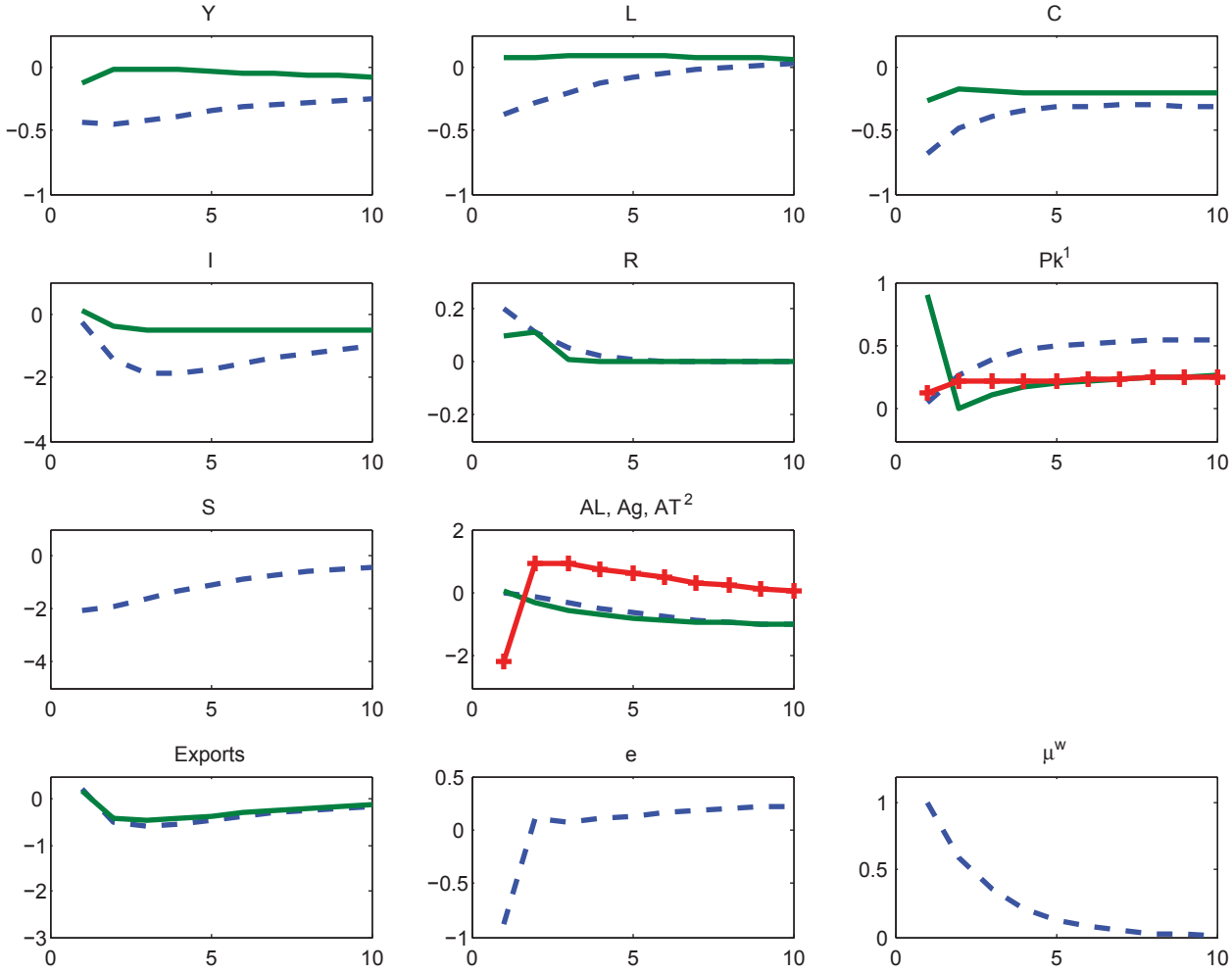

[1] Research and development expenditures (S, --), investments in exporting (Xg,-) and FDI (Xt, -+)

Figure 7: Impulse Response Functions for Mexico Wage Markup,TFP and Price of Investment Shocks
Baseline Model (U.S. dash, Mexico, solid)




[1] Research and development expenditures (S, --), investments in exporting (Xg,-) and FDI (Xt, -+)

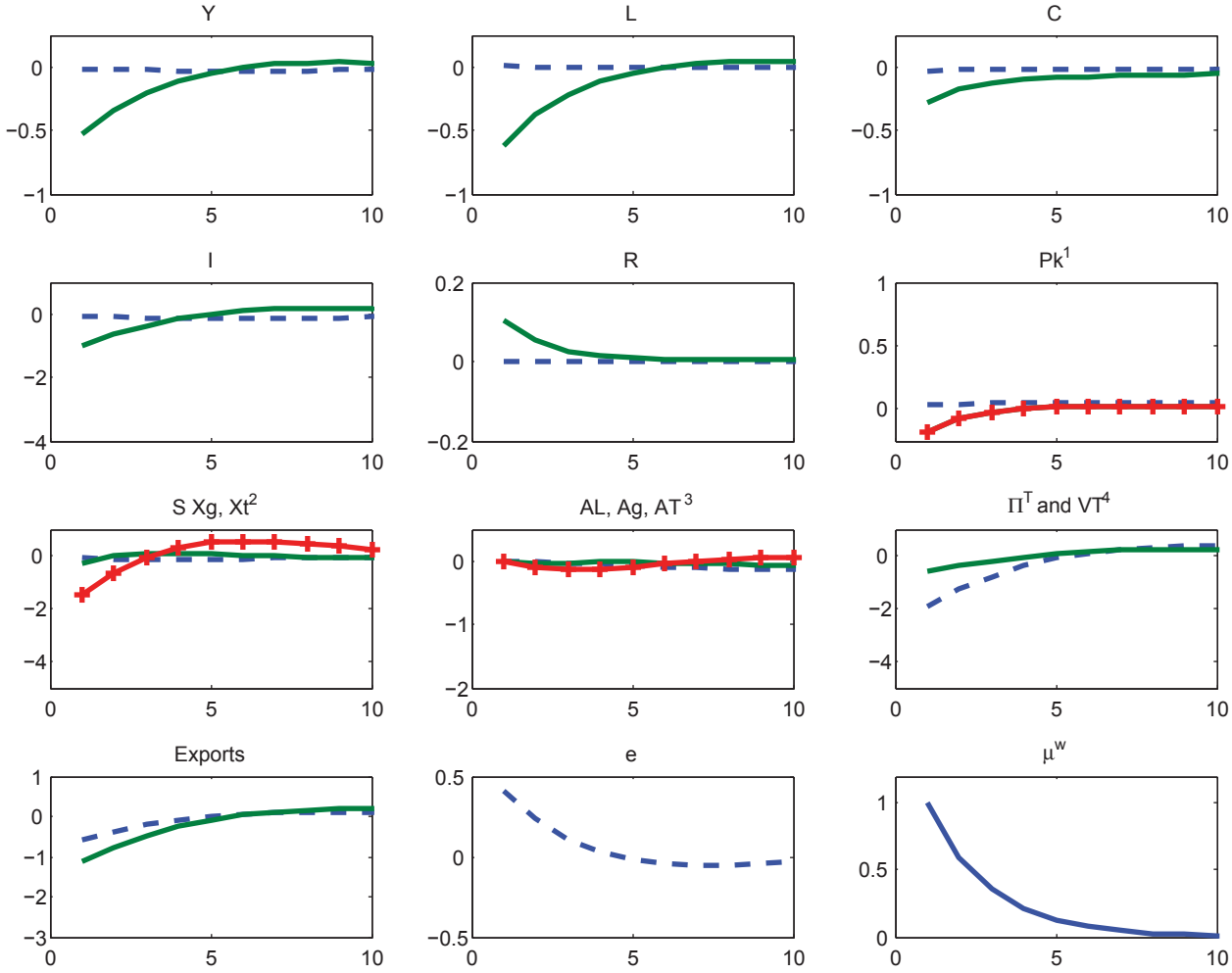
Figure 8: Impulse Response Functions for U.S. Wage Markup Shock in Model with Fixed Costs of International Technology Diffusion. (US dash, Mexico solid)




[1] Price of installed capital in Mexico (+)

[2] Local Intermediate Goods (AL,--), Exported Intermediate Goods(Ag,-) and Transfered Intermediate Goods(AT,-+)

Figure A1: Impulse Response Functions for Mexico Wage Markup Shock,
Model Without Adjustment Costs (U.S. dash, Mexico, solid)




[1] Price of installed capital in Mexico (+)
[2] Research and development expenditures (S, --), investments in exporting (Xg,-) and FDI (Xt, -+)
[3] Local Intermediate Goods (AL,--), Exported Intermediate Goods(Ag,-) and Transfered Intermediate Goods(AT,-+)
[4] Net income from transferred intermediate goods ($\Pi^T$, --), Value of transferred intermediate goods (VT,-)

Table 1A: Relationship between HP GDP in developed economy and GDP in developing filtered at high frequency

| | Developed GDP (HP-filtered) | | | |
|---|---|---|---|---|
| Lags | 0 | 1 | 2 | 3 |
| Developing GDP (HP-filtered) | 0.42*** | 0.29*** | 0.11 | 0.05 |
| Developing GDP (Medium Term Component) | 0.63*** | 0.76*** | 0.61*** | 0.39 |

Note: Coefficients of univariate regression: GDP Developing on GDP Developed. Significance level determined using robust standard errors.

Table 1B: Cyclicality of imported varieties durable manufacturing

| | filtered) | filtered) |
|---|---|---|
| Varieties imported from Developed (HP-filtered) | 0.17*** | 0.62*** |
| Varieties imported from Developed (Medium term business cycle) | 0.12*** | 0.57*** |

Note: Contemporanoeus correlation.

Table 1C: Medium term correlation between varieties imported from developed economy and relative price of

| | Durable manufacturing varieties imported from | | | |
|---|---|---|---|---|
| Lags | 0 | 1 | 2 | 3 |
| GDP developing country | 0.15*** | 0.17*** | 0.12** | 0.03 |
| Relative price of capital developing country | -0.16*** | -0.25*** | -0.31*** | -0.32*** |

Note: All series are filtered using a Band-Pass filter that isolates frequencies between 8 and 50 years.

Notes for Tables 1A-1C

* significant at 10%, ** at 5%, *** at 1%. Medium Term Component filtered using a Band Pass filter that siolates cycles with period between 8 and 50 years.

The developing countries linked to the U.S. are Mexico, Dominican Republic, Costa Rica, Paraguay, Honduras, Guatemala, Venezuela, Peru,

El Salvador and Nicaragua. The countries linked to Japan are Panama, Thailand, South Korea, Philippines, Vietnam, China, Pakistan, Indonesia, South Africa and Malaysia.

Table 2: Calibration

| Parameter | Interpretation | Value |
|---|---|---|
| $\beta$ | Discount factor | 0.95 |
| $\delta$ | Depreciation rate | 0.1 |
| $G_N/Y_N$ | Share of Government Spending | 0.2 |
| $G_S/Y_S$ | Share of Government Spending | 0.1 |
| $U$ | Capacity utilization rate in steady state | 0.8 |
| $\delta''(U) * U/\delta'(U)$ | Elasticity of depreciation w.r.t. $U$ | 0.15 |
| $\zeta$ | Labor supply elasticity | 1 |
| $\mu_c$ | Markup final goods | 1.1 |
| $\mu_k$ | Markup capital goods | 1.15 |
| $L_N/L_S$ | Relative labor supply | 3 |
| $Z_{0N}/Z_{0S}$ | Exogenous relative TFP $N-S$ | 3.35 |
| $\phi$ | Survival probability | 0.9 |
| $b_c$ | Operating cost parameter | 0.05 |
| $b_c^k$ | Operating cost parameter | 0.016 |
| $g$ | Growth rate of TFP | 0.0072 |
| $\chi$ | R&D productivity | 2.69 |
| $\theta$ | Markup intermediate goods | 1.5 |
| $\rho$ | Elasticity of R&D | 0.65 |
| $\xi_N''(1)$ | Adjustment costs | 1 |
| $\xi_S''(1)$ | Adjustment costs | 1.5 |
| $\psi$ | Iceberg transport costs | 0.95 |
| $\lambda^g$ | Probability of international diffusion in steady state | 0.0875 |
| $\lambda^T$ | Probability of production transfer in steady state | 0.0055 |
| $\rho^g$ | Elasticity of international diffusion | 0.8 |
| $\rho^T$ | Elasticity of production transfer | 0.5 |

**Table 3 : Volatility Model vs. Data**

| | High Frequency | | Medium term Cycle | |
|---|---|---|---|---|
| **MEXICO** | **Data** | **Model** | **Data** | **Model** |
| **GDP** | 0.026 | 0.024<br>(0.014 , 0.037) | 0.037 | 0.04<br>(0.019 , 0.07) |
| **CONSUMPTION** | 0.031 | 0.031<br>(0.019, 0.046) | 0.040 | 0.044<br>(0.024 , 0.074) |
| **INVESTMENT** | 0.079 | 0.068<br>(0.03 , 0.12) | 0.082 | 0.12<br>(0.05 , 0.23) |
| **RELATIVE PRICE OF CAPITAL** | 0.029 | 0.016<br>(0.007, 0.028) | 0.042 | 0.035<br>(0.013 , 0.067) |
| **IMPORTS (FROM US)** | 0.090 | 0.050<br>(0.023 , 0.09) | 0.117 | 0.084<br>(0.035 , 0.15) |
| **EXPORTS (TO US)** | 0.090 | 0.060<br>(0.027 , 0.11) | 0.134 | 0.105<br>(0.042 , 0.19) |
| **TRADE SUPLUS/GDP** | 0.014 | 0.020<br>(0.01 2, 0.03) | 0.026 | 0.026<br>(0.013, 0.046) |
| **GROWTH IN INTERMEDIATE GOODS EXPORTED FROM US TO MEXICO** | 0.049 (all)<br>0.047 (dur.) | 0.019<br>(0.01, 0.029) | | |
| **FDI/GDP** | 0.004 | 0.004<br>(0.002 , 0.01) | 0.005 | 0.017<br>(0.006, 0.044) |
| **U.S. GDP** | 0.013 | 0.018<br>(0.01 , 0.027) | 0.015 | 0.026<br>(0.013 , 0.044) |

Note: Period 1990-2006. High frequency corresponds to cycles with periods lower than 8 years and is obtained by filtering simulated data with a Hodrick-Prescott filter. Medium term cycles corresponds to cycles with periods shorter than 50 years and is obtained by filtering simulated data with a Band-Pass filter. The relative price of capital is the investment deflator divided by the GDP deflator. Growth in intermediate goods is not filtered. All stands for all manufacturing sectors while dur stands for durable manufacturing.

**Table 4: Contemporaneous Co-movement patterns**

**PANEL A: Cross-country correlations between Mexico and U.S.**

| | Data | Model |
|---|---|---|
| **GDP** | 0.43* | 0.68 (0.31 , 0.89) |
| **CONSUMPTION** | 0.2 | 0.05 (-0.54, 0.059) |

**PANEL A: Correlation of Mexican Macro Variables with Mexican and U.S. GDP**

| | **GDP USA** | | **GDP MEXICO** | |
|---|---|---|---|---|
| | Data | Model | Data | Model |
| **CONSUMPTION** | 0.02 | 0.06 (-0.54, 0.61) | 0.78*** | 0.61 (-0.01, 0.91) |
| **INVESTMENT** | 0.6*** | 0.77 (0.26, 0.91) | 0.62*** | 0.69 (0.23, 0.93) |
| **RELATIVE PRICE OF CAPITAL** | 0.13 | -0.08 (-0.52, 0.4) | -0.54*** | -0.36 (-0.75 , 0.13) |
| **IMPORTS (FROM US)** | 0.61*** | 0.85 (0.73, 0.93) | 0.83*** | 0.74 (0.32, 0.93) |
| **EXPORTS (TO US)** | 0.68*** | 0.70 (0.37, 0.94) | 0.08 | 0.57 (-0.03, 0.9) |
| **MEXICAN TRADE SURPLUS/GDP** | 0.07 | -0.62 (-0.88,-0.17) | -0.83*** | -0.96 (-0.99, -0.86) |
| **GROWTH IN INTERMEDIATE GOODS EXPORTED FROM US TO MEXICO** | 0.2 (all) 0.28 (dur.) | 0.42 (-0.12, 0.76) | 0.35 (all) 0.42 (dur.) | 0.43 (-0.1, 0.78) |
| **FDI/GDP** | 0.23 | 0.89 (0.66, 0.98) | 0.11 | 0.73 (0.36, 0.92) |

Note: Period 1990-2006. All variables but FDI are scaled by working age population in Mexico. All variables other than growth of intermediate goods have been HP-filtered. The model statistics are the average of the contemporaneous cross-correlations from the Monte Carlo consisting of 1000 17-year long simulations. In parenthesis 95 percent confidence intervals. The relative price of capital is measured by the investment deflator over the GDP deflator. All stands for all manufacturing sectors while dur. stands for durable manufacturing. * denotes significance at the 10% level, ** denotes significance at the 5% level and *** denotes significance at the 1% level.

**Table 5: Cross-Correlogram Across Frequencies**

| | Lags of High Frequency US Output | | | |
|---|---|---|---|---|
| | **0** | **1** | **2** | **3** |
| **MEDIUM TERM COMPONENT MEX GDP** | | | | |
| Data | 0.28 | 0.49* | 0.53** | 0.39 |
| Model | 0.37** | 0.42** | 0.35** | 0.18 |
| **MEDIUM TERM COMPONENT RELATIVE PRICE OF CAPITAL IN MEX** | | | | |
| Data | 0.35 | 0.02 | -0.24 | -0.5** |
| Model | -0.14 | -0.30* | -0.38* | -0.35 |
| | **Lags of High Frequency MEX Output** | | | |
| | **0** | **1** | **2** | **3** |
| **MEDIUM TERM COMPONENT MEX GDP** | | | | |
| Data | 0.45** | 0.32 | 0.05 | -0.16 |
| Model | 0.52** | 0.45** | 0.25 | -0.01 |
| **MEDIUM TERM COMPONENT RELATIVE PRICE OF CAPITAL IN MEX** | | | | |
| Data | -0.13 | -0.32 | -0.34 | -0.22 |
| Model | -0.33** | -0.45** | -0.45** | -0.32 |

Note: Period 1990-2006. High frequency corresponds to cycles with periods lower than 8 years and is obtained by filtering simulated data with a Hodrick-Prescott filter. Medium term cycles corresponds to cycles with periods lower than 50 years and is obtained by filtering simulated data using a Band-Pass filter. The reported measures are the average of the contemporaneous cross correlations from the Monte Carlo consisting of 1000 17-year long simulations. * denotes significance at the 10% level and ** denotes significance at the 5% level.

**Table 6: Decomposition of output volatility**

| | High Frequency | | Medium Term Cycle | |
|---|---|---|---|---|
| | **US volatility** | **Mexican volatility** | **US volatility** | **Mexican volatility** |
| **US Shocks** | 0.97 | 0.64 | 0.98 | 0.66 |
| **Mexico Shocks** | 0.03 | 0.36 | 0.02 | 0.34 |

Note: Share of output volatility in the relevant country at the relevant frequency associated to shocks either from the US or Mexico. High frequency fluctuations are isolated using a Hodrick-Prescott filter with filtering parameter 100. Medium term cycle is obtained by using a Band Pass filter that isolates fluctuations associated with cycles of period shorter than 50 years.

# Chapter 2

# Price-Setting Discoveries: Results from a Developing Country

## 2.1 Introduction

The idea of sticky prices is at the heart of modern day macroeconomics for explaining economic fluctuations over the short horizon. It implies that instead of being vertical, the aggregate supply curve is upward sloping. Therefore, fluctuations in aggregate demand can cause fluctuations in output. This setup is fundamental for monetary policy as it determines the extent to which money growth, with its influence on aggregate demand, can influence the real economy. As it is commonly implied, the lengthier the period between price changes the greater the influence of monetary policy. Therefore, it is quintessential to empirically establish the extent and the nature of sticky prices.

Until recently, there had been a gap between theoretical explanations of price-stickiness and studies of their empirical importance. Partly in response

to this gap and partly because of the apparent success over the last two decades of monetary policy in curbing inflation, central bankers and academics of advanced economies have devoted much resources to the empirical study of price stickiness.[1] To name a few studies Rotemberg (1982), Carlton (1986), Cecchetti (1986), Kashyap (1995), Blinder (1991), Blinder et al. (1998), Taylor (1999), Aspland, Eriksson and Freiberg (2000), Hall, Walsh and Yates (2000), Bils and Klenow (2004), Levy, Datta and Bergen (2002), Amirault et al. (2005) and more recently Fabiani et al. (2007), Nakamura and Steinsson (2008) and Greenslade and Parker (2012). This large literature for U.S. and European countries shows that the degree of price-stickiness is considerable and pricing strategies are complicated.

However, the corresponding effort to study price-stickiness in developing economies leaves much to be desired. Such a study is all the more important in light of the growing literature that documents the contrasting features of the developing world such as: (i) *procyclical* monetary policies, (ii) persistence of inflation levels in the double-digits and (iii) higher than average volatilities of annualized inflation rates (see especially Agénor and Montiel (2010) and Frankel (2010) and the literature therein). Furthermore, with the expected rise of the emerging markets as world economic engines it will become increasingly important to study in detail the behavior of their product markets and the extent to which they differ from that of the developed world.

In this paper, we present results of 1189 face-to-face structured interviews carried out in 2009 to 2011 with entrepreneurs representing formal firms in the manufacturing and services sector of Pakistan. By formal, it is meant that our firms are officially registered, tax liable and also report data to employment agencies. Therefore, these firms necessarily take part in the official GDP and

[1]The European Central Bank has a large team working under the aegis of 'Inflation Persistence Network 'to study prices.

employment statistics. This study is comparable to similar research work in developed countries in that key questions were benchmarked and drawn from the pioneering works by Blinder (1991) and Blinder et al. (1998) for the U.S., Fabiani et al. (2007) for the Euro area and Greenslade and Parker (2012) for the U.K.

The interviewers inquired about the nature of the product market, frequency of price reviews and price changes, key explanations for price-stickiness, dissemination of economic shocks, and the nature of interaction with the informal sector entrepreneurs. Understanding the linkages with the informal sector is important given that in Pakistan the informal economy[2] employs more than 70% of non-agricultural labor force.[3]

To the authors' knowledge, features such as the scale of structured interviews (only Blinder et al. (2007) for US, Amirault et al. (2005) for Canada and to a smaller extent Loupias and Ricart (2004) for France used structured interviews), sectoral coverage, updated list of price theories and questions on the informal sector makes our survey the first exercise of its kind jointly conducted by a central bank and statistical agencies. Furthermore, this study is a good test for the universality of a great number of price theories developed by economists over the last few decades.

A few words on the macroeconomic situation of Pakistan at the time of the interviews (Dec 2009-Jun 2011) before the presentation of key results. In November 2008, Pakistan entered a 23 month IMF program (the 11th since 1988) after a balance-of-payments crisis in May 2008. The average annualized inflation rates for Pakistan during the three months of the interviews in Punjab was 12.5%, and during the year of survey in Sindh was 14%; which is 4-

[2]Informal sector output is at least one-fifth of the reported GDP (see Arby, Hanif and Malik (2010))

[3]Pakistan Labor Force Survey 2009-10.

6% above Pakistan's 50-year trend. During the fiscal year 2010, (i.e. July 2009-June 2010) real GDP grew by 3.8% and the annual unemployment rate was 5.6%.[4] Monetary policy was conducted under a dirty-float, with implicit inflation and growth rate targets of 9% and 3.3% respectively.

We establish twelve stylized facts about price-setting behavior in Pakistan's formal manufacturing and services sectors and compare them with pervious work where possible:

*Fact 1* The median frequency of price changes in the manufacturing and services sector is 6 and 2 times a year respectively. The equivalent figures are 1 and 1.4 times a year in Europe and the US respectively;

*Fact 2* Prices are rigid downwards and more so for the services sector; a result consistent with previous work;

*Fact 3* Formal firms are relatively more sensitive and promptly accommodate to changes in (a) overall cost and in particular that of energy and intermediate inputs, (b) competitors' prices and (c) the exchange rate. However, changes in demand and financial-costs matter less. This is consistent with previous literature for developed countries, with the main difference being that labor costs relative to energy costs were found to be more relevant for them;

*Fact 4* Time dependent price rules are more common than state-dependent ones, with 51% of firms using the former; while for developed economies the same figure is 33%;

*Fact 5* The top three reasons for delaying price changes upwards are: (a) the fear that other firms will not follow, (b) the uncertainty that shocks might be temporary and (c) the fear of customer retaliation. The first and the third reasons are in line with the results from developed economies;

[4]The unofficial unemployment rates are higher, but they are hard to assess as 70% of non-agricultural household′s working hours are spent in the informal sector.

*Fact 6* 37% of owners reported that prices are benchmarked to competitor's price, while 47% reported setting prices on the basis of constant or variable markup. The same figures stand at 27% and 52% respectively for developed countries. However, there is considerable imperfect competition in all types of economies;

*Fact 7* The manufacturing sector–where costs of raw material account for 70% of total cost– responds more to cost shocks relative to the services sector–where labor costs account for 40% of total cost;

*Fact 8* All firms, big or small, use backward and forward-looking information sets in making price decisions. In particular, 46% of firms use a combination of backward and forward looking information while only 29% use pure forecasts. In contrast, the use of forecast information is considerably higher in developed countries, with 55% of firms relying on it;

The remaining facts are particular to the linkages between formal and informal sector as viewed by the formal sector entrepreneurs:

*Fact 9* 43% of formal firms interviewed interact with the informal sector either through demand or supply channels;

*Fact 10* Economies of scale, customer preferences and market power motivates formal firms to remain in the formal sector;

*Fact 11* According to formal firms, tax exemptions and weak enforcement are the main reasons for the existence of informal sector;

*Fact 12* Formal firms with frequent interaction with the informal sector tend to have relatively lower probability of price change suggesting that interactions with informal economy serve as a shock absorber; in particular for demand shocks.

This paper presents results from our survey and compare our results with the US and the Euro Area where possible. The rest of the paper is organized

as follows: Section 2 presents the research design. Sections 3-7 discuss various aspects of pricing. Section 8 presents caveats of our study while a final section concludes.

## 2.2 The Research Design

Generally, there are three approaches to obtaining information on price stickiness at the firm level: (i) using secondary data from which one may infer stickiness, (ii) sending surveys through e-mail or post or (iii) conducting one-on-one structured interviews.

The first approach has the concern that data on economic outcomes is not sufficiently detailed in Pakistan at the firm level for a meaningful study on prices. The second approach has the concern that unlike in western countries in Pakistan, the concept of obtaining qualitative information through e-mail and post is relatively new which might lead to low response rates. Also, there is no guarantee that the survey would be filled by a suitable person in the organization. The concern for the third approach is that it is costly (especially for large sample size like ours) and the length of the survey process may be longer.

We adopted structured-interviews approach for our survey for three reasons: complexity of the questionnaire, potential poor response rate through traditional mail and the fear that questionnaire might not reach the appropriate person. Generally, lower response rates do not necessarily indicate any bias, especially if distributed systematically across the sample. However, we post-stratify our sample results based on firms' size and economic activity to reduces this bias. This proved important as we had a lower response rate for larger firms. Other surveys such as Kwapil et al. (2005) and Loupias and

Ricart (2004) also find similar large firm behavior. Despite the higher cost, face-to-face interviews are considered to produce higher quality results and a higher response rate. They also reduce the possibility of fluke answers, provide direct access to the suitable individual and allow interviewers to carry out a longer list of queries.

Overall, the literature recognizes the potential of Blinder's unorthodox survey approach. Indeed, no less than 17 developed countries have used detailed questionnaires (via e-mail or post) to study the pricing pattern[5] in the manufacturing and services sectors. Nonetheless, with all the qualitative surveys (structured interviews or otherwise) there is the danger of misinterpretation by respondents with the slightest change in the wording of the questions leading to disproportionate responses. In many cases, respondents may use intuition rather than what they do in practice to respond to the questions.

In full recognition of the possibility that these challenges might be more acute for a developing country like Pakistan, we teamed up with the premier statistical agencies of Pakistan.[6] They selected experienced interviewers with local know-how and contacts to conduct our survey. The State Bank of Pakistan provided focused training (both theoretical and practical) to these selected interviewers for complex real world situations, where they need to elaborate and explain the questions for clarity. SBP [7] also conducted two separate pilots before launching the study. For a further quality check, economists from the State Bank randomly audited 10% of live interviews.

The face-to-face interviews took place between December 2009 and June 2011. The study began in the province of Punjab in December 2009 and ended in March 2010. In the province of Sindh, it was launched in June 2010 and

[5]The U.S. used structured interviews.

[6]These agencies are well-equipped for this exercise as they conduct the census of the manufacturing sector in Pakistan.

[7]State Bank of Pakistan, which is the Central Bank of the country.

ended in October 2011. [8]

### 2.2.1 The Questionnaire

The questionnaire is benchmarked to Blinder (1991) and the collection of studies in Fabiani et al. (2007). This is imperative as it allows us to draw parallels between price-setting behavior of firms in developing and developed economies where possible.

In line with previous work, section A of our questionnaire contains questions on the general profile of the firm as well as queries on the types of customer and the nature of competition in their respective market. Section B, C, and D contain questions on various aspects of price setting of the main product–the one with highest domestic sales. Section E contains queries on existing theories of price-stickiness and dissemination of shocks. Section F contains queries on the interlinkages between the formal and informal sectors.

In order to better capture the ground realities of the Pakistani economy, the questionnaire was customized in the following ways: First, we asked formal firms about their interactions and views on the informal sector. Second, we asked entrepreneurs about breakdown of their cost structure. Third, in the section on price-dissemination we paid particular attention to the effects of external shocks on prices. Indeed, Pakistan is exceptionally vulnerable to external shocks with 11 IMF programmes since 1988.[9] This is important as little is known about shock transmission in developing countries at the micro level.

On the testing side, the newly designed questionnaire was tested between ourselves and crucially on a separate sample of 50 randomly selected firms in

[8]The main reason for delay in completion of surveys in Sindh was the precarious law and order situation during the period of surveys

[9]See www.imf.org.

Karachi;[10] The final questionnaire was then translated into Urdu.[11] We have attached the questionnaire in Appendix C.

### 2.2.2 Sampling

We covered the 'formal' manufacturing and services sector in the provinces of Punjab and Sindh. The other two provinces of the country (Balochistan and Khyber-Pakhtun Khwa) were avoided due to safety reasons at the time of the interviews. Our focus on the lager provinces and sectors ensures that our results are a good representation of the pricing pattern of the formal sector in Pakistan.

The population frame for the manufacturing sector consists of all firms which reported in the last census of manufacturing industries (CMI). The manufacturing sector is dominated by certain types of economic activities as well as having a greater share of small sized firms. Therefore, a purely random sample would run the risk of having a bias towards these activities and firms. To overcome this problem, stratified random sampling was used.

The firms were stratified on the basis of economic activity and firm size. The manufacturing sample covers firms with International Standard Industrial Classification (ISIC) economic activity codes from 15 to 36 (excluding 30).[12] The population of firms for the above mentioned sub-sectors of the manufacturing sector was split into three categories of employment brackets: 10-50,

[10]Pakistan's largest metropolis.

[11]Pakistan's national language.

[12]The activities are: 15-(food products & beverages), 16-(tobacco products), 17-(manufacture of textiles), 18-(wearing apparel), 19-(leather products), 20-(wood & wood products), 21-(paper & paper products), 22-(publishing, printing & reproduction), 23-(petroleum), 24-(chemicals & chemical products),
25-(rubber & plastics products), 26-(other non-metallic mineral products), 27-(basic metals),
28-(fabricated metal products), 29-(machinery & equipment N.E.C.), 31-(electrical machinery & apparatus), 32-(Radio,TV & communication equipment), 33-(medical & optical instruments), 34-(motor vehicles & trailers), 35-(other transport equipment), 36-(furniture).

51-250 and more than 250 employees. On the basis of these classifications, a random sample for the manufacturing sector was drawn from 63 mutually exclusive strata. We drew a sample of 1200 firms for the manufacturing sector in Sindh and Punjab, along with a replacement-sample representing 50% of the original sample to cover the possibility of non-response. In case of non-response, a firm from a particular stratum was replaced by another firm from the same stratum to maintain sectoral representation.

The sampling for the services sector is more complicated in that there is no formal population frame available for firms in the services sector. Therefore, we used the database of Securities and Exchange Commission of Pakistan (SECP) which maintains a complete list of firms registered with them. However, the SECP frame lacks information on firm size and dormant/ non-dormant status of firms. Therefore, we impose the following constraints on the sample selection in the services sector. First, to minimize the chance of selecting dormant firms from a massive database, we only selected firms that had been registered within the last 10 years and if registered before that time period have reported to SECP at least once in the last 10 years.[13] Second, to avoid small firm bias, only firms with paid-up capital more than RS. 2,000,000 (USD 23,500) were selected in our sample .Third, we only included firms involved in economic activities where it is possible to identify a main service. A random sample of 270 firms was selected from transport and telecommunication, hotels and restaurants, education and health care services on the basis of sectoral distribution. With the above limitations, results for the services sector should be interpreted cautiously as they only reflect price-setting behavior for selected services and not from a well-defined sample frame. We, therefore, present services sector results separately as well.

[13]Every firm registered with SECP has the obligation to report its statistics on annual basis but few do so on a regular basis.

Table 1 provide details of the sample. As of June 2011, 1189 structured interviews were completed. Of these interviews, 1025 are from the manufacturing sector with 286 (that is 28%) out of 1025 from the Sindh province. The services sector accounted for 14% of the sample. In practice, most of the price-setting surveys in the Euro Area are biased towards the manufacturing sector, due to particular nature of price-setting surveys.

A few thoughts on the sample size before we discuss the results. The sample size of 1189 manufacturing and services sector firms makes our survey the fifth largest price survey among the existing European and U.S. surveys. Also, to best of author's knowledge this survey is first of its kind for an emerging economy like Pakistan. The covered sample of 1025 firms in the manufacturing sector is about 9.4 % of the target population, which is well above the usual convention of choosing a sample of about 5 % of the population. However, sample for the services sector was selected as a small proportion of a pseudo-sample because of the non-availability of any formal population frame as discussed earlier.

In order to make sure that our sample is a good representation of the population, we allocated the sample according to respective strata shares in population. However, for stratas with very small share in population sample size was deliberately increased to be able to make stronger statistical inferences for them. The allocated sample was then drawn randomly from sample frames. For very small stratas, we included all of the firms from such stratas in our sample.

To draw valid inferences for the population on the basis of this sample, it was necessary to post-stratify the data to control for possible selection bias due to either closure of some selected firms, firms being sole-exporter of their product or firms shifting to a different economic activity. Similarly, large firms'

decisions are likely to be more important. Also, we had lower response rate from larger firms so data needed to be adjusted for firm size as well. Furthermore, aggregate weighted results appear under the nomenclature of 'total 'in our Tables. For this, we reweighed the data on the basis of sector weights in the population. Appendix B contains the details of the post stratification scheme.

The manufacturing and services sectors combined to account for 71% of GDP in 2010. However, taking only into consideration the subsectors that are covered in our interviews, our final sample is representative of firms that produce around 25.2–27 % of Pakistan's GDP. The under-representation of the services sector is noticeable but common in other international price related studies as well. This is because it is not straight forward to define the main product for some services sector firms. Services like financial services, construction, retail and trade were not included where product usually changes with every transaction. Also, in our case the sample frame for the services sector was not available. Given the list of subsectors in the manufacturing and the services sectors, on aggregate we believe to have captured a true picture of '*price-setting*' in Pakistan with identifiable products.

## 2.3 The Environment

To a great extent, price determination and its adjustment depends on the market structure. The structured interview approach addresses this issue by asking about firm size, importance of the main product for the firm, firm's position in the market, and the nature of firm's relationship with customers.

The questions in our structured interviews focused on the dominant product of a given firm in terms of turnover in Pakistan. In manufacturing and

services sector, we found that on average turnover generated by the main product is 77% and 85% respectively. Furthermore, the national market was the main market for 95% of manufacturing and 86% of services sector firms for their main product in our sample. This implies that our survey results present a representative picture of pricing pattern at the firm level in Pakistan. This suits our needs as we are primarily interested in understanding the pricing-pattern in Pakistan.[14]

As for the interaction with customers, the majority[15]of manufacturing sector firms sell their main product to other firms. While in services sector 58% of the firms directly deal with final customers. This implies that the results of our interviews refer to producers prices for the manufacturing sector and customer prices for the services sector. Furthermore, for firms in our sample the majority of customers (56% manufacturing and 36% services) tend to be repeat customers. However, the share of repeat customers in our sample of Pakistani firms is less than Europe, where 70% of sales are based on long-term clients.

Table 3 eludes to the degree of competition in manufacturing and services sectors. Majority of firms perceive market competition to be high or very high in the industry. The share of firms claiming to operate in a medium or weak competition is 24% and 18% for manufacturing and services sector respectively. This implies that markets are more competitive in Pakistan than in Euro Area where 40% of firms perceive competition to be weak. This finding is further corroborated by the fact that 37% and 41% of firms in the manufacturing and services sector respectively place themselves not to be amongst the top ten firms.

[14]International penetration of the main product for formal sector firms in Pakistan is at least three times lower than the Euro Area.

[15]80%

In sum, it is possible to infer that there is a monopolistic environment in Pakistan with firms usually having long-term relationship with customers. However, this environment is more competitive than Europe and the proportion of firms with long-term relationship with customers is smaller.

## 2.4 A Profile of Price Setting

Most New-Keyensian economists believe that the slow adjustment in prices and wages play an important role for explaining short run economic fluctuations. However, New-classical economists argue that prices are flexible, even in the short-run, and that explanations for economic fluctuations must be found elsewhere in factors such as technology shocks and preferences. These differing views fundamentally affect the choice of the critical assumption of perfect vs. imperfect competition in product and labor markets for the purpose of building any general equilibrium model of the economy. Therefore, it is essential to get a solid empirical grasp on the extent and the nature of price and wage stickiness in Pakistan.

This section is devoted to price-setting behavior of firms in our sample, namely, the basis on which prices are set, revised and frequency of price change. In the previous section, we found some indication of imperfect competition in Pakistan. This result is further confirmed by the finding in Table 4 that 34% and 63% of firms in the manufacturing and services sectors reported applying the markup rule of pricing. Overall, 47% of formal sector firms in our sample use the markup rule.[16] A further 44% and 29% of manufacturing and services sector firms reported following their competitors in setting prices. Overall, the numbers are not too different from the results in Europe, with the main

[16]Surprisingly, 'markup' is commonly used in Pakistan to denote unit profit margin in the local language.

difference being the relatively higher use of the markup rule in the services sector in Pakistan.

These results further support the existence of imperfect competition in Pakistan and the idea that firms set prices themselves. Next, we turn our attention to main reasons for price reassessments. To establish these features, we ignore prices determined by government. The academic literature identifies three main methods of price evaluation: (i) at regular time intervals Taylor (1980) and Calvo (1983) (ii) on the basis of specific events Barro (1972), Sheshinski and Weiss (1983) and Caplin and Leahy (1997) and (iii) a combination of the former two. It is also possible for firms to adopt both methods of price adjustment. Indeed, it is reasonable to expect firms to accommodate for specific changes even when they generally adhere to a time interval approach for price changes; this idea was first debated in Hall et al. (2000) then further taken by Apel et al. (2005).

In Table 5, the estimated weighted average of firms that review their prices at regular time-intervals is 51% and a further 9% of firms review prices generally at regular time intervals, while also accommodating for specific events. This implies that 60% of the firm change prices on the basis of time-dependent rules. These numbers are similar to Blinder et al. (1998) for US and Hall et al. (2000) for UK where the figures are 60% and 70% respectively. In contrast, European figures from Fabiani et al. (2007) of 34% and for Sweden of 44.8% in Apel et al. (2005) are far lower. This difference may be due to their market structure, with a significantly higher proportion of long term customers and also the fact that Sweden and Euro Area had lower inflationary environment at the time of their surveys. Therefore, for firms in their sample prices reviews were only necessary on specific occasions. In the case of Pakistan, 50 year trend inflation of 8% implies that it is imperative for firms to reassess prices

more regularly. Table 5 also provides a breakdown of price reassessment approaches taken by manufacturing and services sector and by firm size. Both sectors are similar in the way prices are reviewed. Moreover, the firm size is positively correlated with the regularity of price reviewing.

We now turn our attention to different measures of prices stickiness. This is crucial as it determines the extent to which monetary policy can have a real impact on the economy. As discussed earlier, frequent changes in prices lower the length of price spells by making the aggregate supply curve steeper. In Table 6, we discuss the key measure of price-stickiness by directly asking entrepreneurs about their actual number of price changes in a typical year.

The median[17] number of price changes in Pakistan is 3 times a year. This is almost 3 times higher than what is found in the developed world. This implies that median spell of a price change is 4 months. Furthermore, 24% of the firms change their prices within a month; once again greater than what is found in studies on the Euro area and US respectively.

We also discover in Table 6A, that at a disaggregate level, manufacturing sector prices are much more flexible than prices in the services sector and firm size positively impacts the median frequency of price changes. This implies that for manufacturing duration of price spells is no longer than 2 months. The latter results are also found in the developed economies but their significance is not as sharp. It is also noticeable that small and large firms have similar median number of price changes. The find that Pakistan, with a steady-state year-on-year inflation of 8%, has a greater frequency of price change than developed economies compares favorably with studies such as Cecchetti (1986), Kashyup (1995), Buckle and Carlson (1995) and Taylor (1999) which observe

[17]The mean would be a misleading measure of central tendency in this case as some firms change their prices on continuous basis. For these firms we assume that prices change on daily basis to simplify our analysis.

that during periods of high average inflation the duration of price-spells tended to be shorter in the countries of their interest.

Price adjustments downward show a different pattern. In Table 6B, we can see that median price cuts happen once a year for the manufacturing sector, while for the services sector this is only true over a long period of five years. Overall, for both manufacturing and services sector price cuts tend to occur after two and half year showing considerable amount of downward price rigidity.

In sum, there are price rigidities in Pakistan, but far less than what is found in developed economies. There is a higher degree of price rigidity in the services sector compared to the manufacturing sector. The empirical evidence presented on price stickiness, with a higher frequency of price change, have important implications for policy-making in Pakistan.

First, monetary policy in such an economic environment would have a smaller impact on real economy than in an environment with a lower frequency of price change. This happens because a smaller proportion of firms will have their actual prices different from the optimal levels giving the policy maker a very small window of opportunity to affect output.

To reiterate this point further, let us make the unlikely assumption that all features of the Pakistani economy resemble that of the U.S. economy with the exception of the frequency of price change as reported in Table 6. We plug this information in a simple Dynamic Stochastic General Equilibrium (DSGE) model of the U.S. In our version, nominal price rigidity is the only source of friction with all other standard ingredients such as monopolistic competition in the product market, monetary policy and balanced budget. In Fig.1, we present the impact of a one standard-deviation interest rate shock on the output gap. The real impact of a policy shock on output for Pakistan is

smaller, with the brunt of its effect dying out within three quarters. While on the other hand, for the US case output falls 17% below its potential and effects of policy shock dies out only after the 17th quarter. This simple exercise shows that only using assumption of price-rigidity to explain economic fluctuations and persistence in real variables in emerging markets such as Pakistan may not be the best idea.

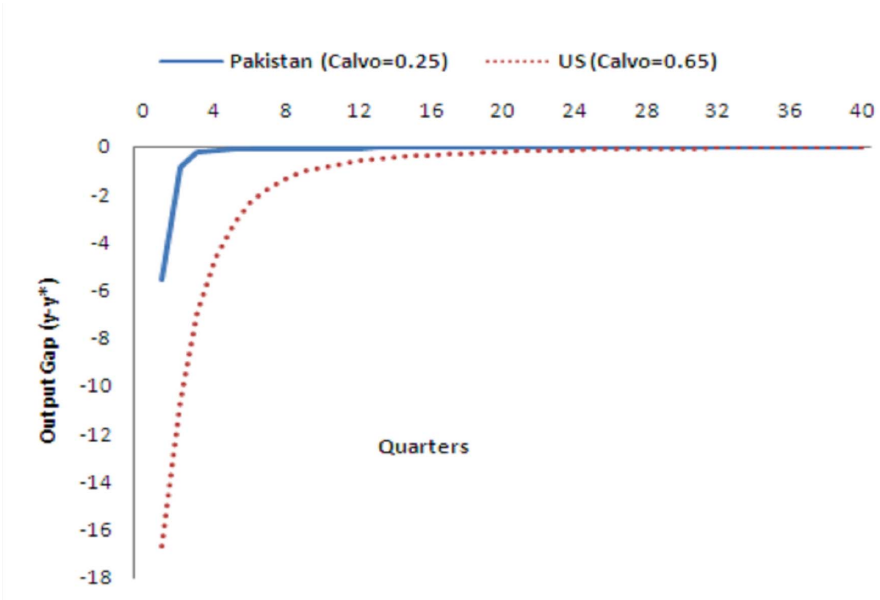



Figure 2.1: The impact of an interest-rate shock on the output gap $(y - y^*)$.

Second, the higher frequency of price change calls for policy-making and analysis to be based on data that is at a frequency better than quarterly and quarterly at worst. This is confirmed by the Calvo [18] probabilities in Table 6 which show that prices are optimized within a quarter.

Third, the finding that time-dependent rules are also applicable to economies with high inflation and high frequency of price change has not been documented previously in the literature to our knowledge. The potential reason behind this puzzle is the frequency of price reviews. Price review within a

[18]Calvo probability refers to the probability that a firm cannot change its price during a given period.

month is the most common practice in the Pakistani markets, where for US and Euro area only 25% of firms review prices within a month. The time dependent firms with a high frequency of price reviews indicate that despite following a time-dependent rule for price change, the probability of re-optimizing prices increases with significant differences between original and optimal prices. The behavior of such firm is likely to resemble state dependent firms. Note that our pattern of pricing appears not to be conditioned by the choice of year as the firms provided similar answers to what they actually did in 2008 and 2009.

These results naturally raise an important question for developing economies such as Pakistan. Models based on time-dependent rules with fairly low frequency of aggregate price change and where these changes are staggered are the mainstay of monetary economics for explaining persistence in inflation and output. However, it seems not to be the most appropriate way to model behavior of Pakistani economy.

We have already learnt that formal sector firms in Pakistan change prices more frequently than firms in developed countries, but what stops them from changing prices even more frequently. To answer this question we presented firms with an extensive list of statements, based on a manifold of theories, and asked them to identify the ones that were used in the practical sense for delaying price adjustments.

Firms were asked to evaluate importance of different pricing theories for their pricing decisions on the scale of: very important, important, of minor importance and unimportant. The responses were coded from 1 to 4 respectively. The responses for the manufacturing and services sector were used to rank different theories. In Table 7A, we present the results of top five explanations for the manufacturing and the services sector. For comparison, we also present the results from U.S. and Euro Area.

The top three explanations for delaying price adjustment are: (i) firms prefer to act once they have observed how their peers behave (82% of the firms ranking this aspect important or better) i.e. firms care about relative prices (ii) the fear of customer retaliation (48% of the firms ranking this aspect important or very important) and (iii) the perception that shocks might be of temporary nature (44% of the firms ranking this aspect important or very important). Generally, our results are closer to the US than the Euro Area, Hall et al.(2000) for UK and Apel et al.(2005) for Sweden. This should be expected given that the median frequency of price change in the US is relatively higher than elsewhere. The ideas of implicit contracts, costly price adjustments and costly information appear at the bottom of our ranking. The latter two theories performed especially badly in other surveys as well. For details of mean scores see Table 7B in the Appendix.

We also asked firm owners separately if any of the relevant theories in Table 7A hindered them from marking down prices. In response, the top two explanations stayed the same as in Table 7A. However a different theory was ranked third (with 64% of firms choosing it) and it is that firms refrain from reducing prices during bad times as it hurts their cash flows.

These results are reasonable for Pakistan considering its higher frequency of price changes. For example, it is hard to imagine a formal price-agreement in the manufacturing sector when the typical price duration is only 2 months. However, in the services sector where the median price change is twice a year, explicit contracts make more sense and were also reported as the third most mentioned reason for price stickiness.

## 2.5 Factors Determining Price Adjustment

There are four key ingredients of price determination. First, what drives price changes. Second, differences in firm behavior when prices go up as opposed to when they go down. Third, the speed with which different shocks are incorporated into prices. Fourth, the type of information used during the decision making. We have briefly talked about points two and three in the context of demand and supply shocks but we explore each of these aspects in detail below.

It is important to highlight that firms are more concerned with price increases rather than reductions. Indeed, the median frequency of price decreases for manufacturing and services sector firms over the last five years prior to the interview are 5 & 1 respectively. With this in mind, analysis on factors leading to price reductions should be taken with a pinch of salt.

In Table 8, we report causes of price changes and the approximate speeds with which these changes pass-through to prices. The top four reasons for prices to go up or down for the manufacturing sector are raw-material costs, energy costs, exchange rate movements and the competitor's price. For the services sector, raw-material cost matters less while labor cost matters more due to their cost structure. In Table 8, we also report how quickly important changes are incorporated in prices for these reasons. The most important reason for a price change gets incorporated in decision-making within a span of three months. Other less important reasons are incorporated in pricing decisions within six months. In the case of the Euro area, costs are also more important but with the difference that raw material and labor cost rank higher when prices go up while raw-material costs and competitor's price matter more when prices decrease. These differences can be explained by the nature of market and cost structure of the manufacturing and service sector in Pakistan.

We do not have equivalent speeds of adjustment available for other countries for comparison.

Table 8 also tests the asymmetry of mean lag of prices changes for given reasons. We find that for most of the reasons it takes significantly longer on average to markdown prices then markup except for general price level in the manufacturing sector, and demand changes and labor productivity for the services sector.

In Table 9, we present the breakdown of firms' cost structure in 2009. We find that local and imported raw-material costs account for 70% of total cost in the manufacturing sector, which explains the presence of exchange rate and local raw material costs as prime forces driving price changes.

Next, we asked firms about the type of information they use for determining prices of their main product. We focused on finding out whether price setting is based on information referring to past, future or a combination of both past and future. This is important as it can shed light on the sources of inflation persistence from the point of view of businesses. According to Table 10, 46% of all formal sector firms use a combination of past and future information. Combining this information with firms using only historical data, 71% of the firm use backward-looking information as part of their price-setting mechanism. Furthermore, we find that 71% and 70% firms in the manufacturing and services sector respectively use backward looking rules. The predominance of backward-looking rules in our sample contrasts with that of Fabiani et al.(2007), where the fraction of firms practicing backward-looking pricing relative to those making price decision on the basis of forecasted data is the reverse of what we discovered in Pakistan.

These results on price determination have important policy implications. First, for an economy that reprices at least 12.2% of its GDP (manufactur-

ing sector) six-times-a-year and has lower responsiveness to financial costs compared to exchange rate, inflation stabilization policies should pay more attention to exchange rate policies. This repricing reflects the cost structure, where one-quarter of the inputs (imported raw material and energy to some extent) have an exchange rate component. Second, frequent repricing by firms may also be a reflection of the lack of trust on the policy-makers to stabilize an economy that has gone through an IMF programme no less than 11 times over the last two decades.

## 2.6 Linkages with the Informal Economy

An innovative part of our survey is that we ask formal firms about their existence in the formal sector and their connections with the informal sector. As mentioned before, In Pakistan employment in the informal sector accounts for 70% of the non-agriculture labor force, with 21% of these jobs belonging to manufacturing type activities. Meanwhile, formal sector employment for the manufacturing sector is 20%. Given the size of the informal economy and its overarching presence in the manufacturing sector, it is important to understand the linkages that might exist between the product markets of formal and informal sector.

The literature on the informal sector is mostly concentrated on the labor market (see Perry et al. (2007) for a comprehensive review). The literature reveals four dominant views on the existence of the informal sector: (i) dualist view, which argues that informal sector is comprised of marginal activities Hart (1973), (ii) structuralist view in Moser (1978) and Castells and Portes (1989), which says that firms in the informal economy are subordinates to large enterprizes in the formal sector allowing the latter to cut costs and hence improve

competitiveness, (iii) the legalist view of de Soto (1989 and 2000), which says that cost, time and effort of legislation is at the source of informal sector and (iv) voluntarist view akin to Hirschman (1970), in which entrepreneurs make a conscious decision to remain in the informal sector having done a cost-benefit analysis.

These differing views lead to a variety of interplay between the formal and informal sector to explain labor market issues in developing countries. We think that these theories are equally important for the product market behavior; a connection largely ignored in the literature. The price-setting behavior in the formal sector, and hence its consequences for inflation and output, would be different for structuralist view as opposed to dualist view. The structuralist view of informality allows the formal sector to be more competitive, whereas in the dualist approach the link between formal and informal sector is nonexistent.

Therefore, realizing the importance of the interplay between the formal and informal sectors in determining prices, we asked formal firms in our interviews about their views on the existence of the informal sector. In addition, we also asked them about the extent and nature of their interaction with firms in the informal sector.

In Table 11, the top three reasons for firms operating in the formal sector are: (i) customer preferences, (ii) economies of scale and (iii) market power. Together these imply that a Dixit-Stiglitz type setup is most relevant for modeling the formal sector. Surprisingly, seeking access to formal financial and overseas market appears to be of little importance.

Similarly, we presented firms with a list of possible concerns that they face in the formal sector. The mean scores are presented in Table 12. The top three concerns for both the manufacturing and the services sector are: (i) product

standardization, (ii) costly entry and exit and (iii) discriminatory electricity charges.

We now move on to one of the most interesting parts of the interview, where we asked formal firms about their linkages with the informal sector. In Table 13, we find that 58% and 22% of firms in the manufacturing and services sector respectively interact with the informal economy. To put it in the aggregate context, approximately half of firms that produce one quarter of Pakistan's GDP are affected through demand or supply channels of the informal economy. Naturally, it is important to find out the nature of this interaction. There are three channels of interaction (i) demand channel in which informal firms compete for market share with their formal counterpart, (ii) supply channel in which informal firms supply inputs to formal firms and (iii) combination of (i) and (ii).

For the manufacturing sector, 58% of firms are affected by the informal sector through demand and supply channels. The nature of interaction with the informal sector is weaker for the services sector, with only 22% of the firms reporting an interaction with the informal firms through demand or supply channels. The results for the services sector are expected as the informal sector may find it tough to reproduce and/or co-produce intangible goods provided by their formal counterparts.

Looking at these results from the viewpoint of firm-size reveals that, overall, formal firms of different size have similar level of interaction with the informal sector through demand or supply channels. But there are subtle differences in the type of interaction. In particular, small and medium sized firms have much bigger supply-side interlinkages when compared with larger firms while the opposite is true for demand-side interactions.

On the demand side, we find that on average the market-share of the infor-

mal firms in the manufacturing is one quarter, while for the services sectors it is close to one-third. On the supply side, informal sector provides input worth one-third of costs for all those firms using informal economy inputs. When we asked formal firms about why they use the informal sector as a partner in their supply-chain, the top most reply was their 'flexibility' as input suppliers.

Finally, we asked firm owners to rank a list of reasons for the existence of the informal economy. According to formal entrepreneurs, the top four reasons for the existence of informal sector are lack of taxes, poor compliance (hence enforcement), simple production process and costless entry and exit respectively for the manufacturing sector. For the services sector, the top two reasons are same but cheap labor is ranked third. The result on lack of enforcement is in line with Dabla-Norris, Gradstein and Inchauste (2008). Surprisingly, the least important factor for the firms to exist in the informal sector according to formal sector firms is the lack of resources.

Given the above results, one can conclude that according to formal firm owners, the informal sector entrepreneurs are thriving both as producers and as input suppliers. This finding is especially relevant for the manufacturing sector. Furthermore, formal firms with the highest level of interaction with the informal sector also display greater degree of nominal price-rigidity.

These results tend to support the structuralist view of informality, the idea that there are input-output linkages between the formal and informal sector, and the voluntarist view, the idea that entrepreneurs are choosing to stay out of the formal sector, as possible explanations for the existence of the informal economy.

However, this can not be conclusive, as the results presented here only reflect the view of formal firm owners about the informal sector. The robustness of these findings can only be confirmed with our forthcoming paper on

price-setting in the informal sector.

## 2.7 Econometrics of Pricing

To test the robustness of some of our results, we now examine how the number of price changes per year depends on certain features of the market structure using simple OLS regressions. The features we incorporate rest on earlier discoveries and also well-known textbook theories namely: (i) firms with higher share of market are less likely to change their prices (ii) firms claiming to be in highly competitive markets, 'mark-to-market' and hence adjust their prices more frequently (iii) customer-markets, where firms with a larger proportion of direct sales to clients on regular basis, have stickier prices, (iv) firms with flatter marginal cost curve are less likely to change their prices, (v) less commonly known works of Moser (1978) and Castells and Portes (1989) argue for the structuralist view that firms in the informal economy assist larger enterprizes in the formal sector enabling them to improve competitiveness and (vi) Hirschman (1970)'s voluntarist idea that firms stay out of the formal sector out of choice.

To reflect these discoveries in our empirical model we use a variety of variables. To capture the size of the firm, we introduce two dummies for firm size, *MEDIUM* (set to 1 if number of employees are between 51 to 250 for the manufacturing sector and paid-up capital between Rs.15-50 mln for the services sector) and *LARGE* (set to 1 if firm has more than 250 employees for the manufacturing sector and paid-up capital more than Rs.50 mln for the services sector). The type of economic activity is captured by *MANUF* dummy which is set to 1 for firms belonging to manufacturing sector and zero otherwise. The dummy *PROVINCE* is set equal to 1 for province of Punjab.

The dummy variable for market share *MARKET* takes the value 1 if firm is among top four firms and 0 otherwise. The share of turnover generated through direct sales to consumers is captured by variable *HH*. The dummy *INF* takes the value 1 if firm has some interaction (either from demand or supply sides) with informal sector of economy. The dummy for exporting firms *EXP* takes value 1 if firm is exporting its main product and 0 otherwise. The Ordinary Least Square regression with frequency of price changes on the left-hand-side, $y$, yields the following results.

$$\begin{aligned} \text{y} = & \underset{(15.24^{**})}{36.6} - \underset{(6.35)}{9.9}\ \text{MEDIUM} - \underset{(13.02)}{1.5}\ \text{LARGE} + \underset{(15.8)}{23.4}\ \text{MANUF} - \underset{(11.2)}{5.3}\ \text{PROVINCE} \\ & - \underset{(8.7^{**})}{17.3}\ \text{MARKET} - \underset{(6.80^{**})}{14.2}\ \text{EXP} - \underset{(8.25^{**})}{18}\ \text{INF} - \underset{(0.16)}{0.22}\ \text{HH} + \text{error} \end{aligned} \tag{2.1}$$

$R^2$: 8.4% Number of Observations= 1099 S.E.= Brackets.

The number of changes in price are significantly less for firms with higher market share. We also find weak evidence (p-value: 0.16) for customer market theory (Phelps and Winter, 1970) that reckons that firms with higher share of consumers tend to have stickier prices. In a similar vein, firms exporting their main product also tend to change prices less frequently as well as those interacting with the informal sector. We estimated different combinations of eq.(1) using the given set of variables, our results appear to be robust to these modifications. The explanatory power of the regression remains very low (8.4%) due to the diversity of market environment in our economic activities.[19]

Previously, in Table 8, we showed that cost related factors topped the explanations for upward price adjustment.

Next, using a probit regression we estimate the extent to which this key

[19] Apel et al. (2005), also faced similar difficulties.

decision[20] is influenced by the set of independent variables in eq.(2). The left-hand-side variable in this scenario is the decision to change prices upwards due to a positive cost shock. This is captured by the dummy,$c$, set to 1 if firms ranked overall cost as either very important or important for adjusting price upwards.

$$\begin{aligned} c \;=\; & \underset{(0.32)}{0.5} + \underset{(0.21)}{0.20}\ \text{MEDIUM} + \underset{(0.53)}{0.45}\ \text{LARGE} + \underset{(0.25^{*})}{0.43}\ \text{MANUF} - \underset{(0.219)}{0.24}\ \text{PROVINCE} \\ & - \underset{(0.28)}{0.01}\ \text{MARKET} + \underset{(0.35^{*})}{0.62}\ \text{EXP} + \underset{(0.2)}{0.32}\ \text{INF} - \underset{(0.003^{*})}{0.001}\ \text{HH} - \underset{(0.25^{**})}{0.5}\ \text{MC} + \text{error} \end{aligned} \tag{2.2}$$

$R^2$: 16.3% Number of Observations= 1167 S.E.= Brackets

The above probit results show that the probability of changing prices upwards, given a positive cost shock, is higher for firms belonging to the manufacturing sector as well as for those that export their main product.This result mainly reflects the composition of their cost structure.The probability of changing prices upwards due to cost shocks tends to decreases for firms coming into direct contact with consumers in their overall customer base, supporting the customer market theory with (p-value = 0.06). This is contrary to the last model. Furthermore, flatter marginal costs imply a lower probability of pass-though to prices where the variable, $MC$, is a dummy set to 1 for those firms indicating costs being rigid as output expands. Finally, in terms of pass-through of cost shocks to prices, any type of interaction with the informal sector is unimportant. This result does not bode well with the structuralist view of the informal sector which emphasizes the role of informal sector on the cost side of formal sector firms.

Next we consider the same exercise as in eq.(2) but for a positive demand shock, i.e. factors that determine the probability of revising prices upwards

[20]For positive cost shocks only, with downward rigid prices positive cost shocks are more relevant compared to negative ones

given a positive demand shock. This effect is captured by the dummy, *d*, which is set to 1 for firms ranking demand shocks as being either important or very important for upwards price revisions and zero otherwise. The results are as follows:

$$\begin{aligned} \mathrm{d} = & \underset{(0.28)}{0.15} - \underset{(0.19^{**})}{0.45}\ \mathrm{MEDIUM} + \underset{(0.31)}{0.22}\ \mathrm{LARGE} + \underset{(0.241)}{0.12}\ \mathrm{MANUF} + \underset{(0.2)}{0.12}\ \mathrm{PROVINCE} \\ & - \underset{(0.22^{***})}{0.85}\ \mathrm{MARKET} + \underset{(0.28)}{0.33}\ \mathrm{EXP} - \underset{(0.2^{**})}{0.49}\ \mathrm{INF} - \underset{(0.003^{***})}{0.01}\ \mathrm{HH} + \mathrm{error} \end{aligned} \tag{2.3}$$

Eq.(3) indicates that the probability of price-increments fall significantly following a positive demand shock when firms have higher market share, interact more with consumers directly and the informal sector and belong to the medium-size firm category. The above evidence tends to support the voluntarist view of the informal economy in that influence on formal sector firms' prices is being exerted by competition from firms in the informal economy.

## 2.8 Caveats

Despite all the interesting results, this study is subject to shortcomings. One of the most important caveat of this study is the possibility that questions in our structured interviews were answered by respondents in the context of current high inflation[21] environment prevailing in the economy.

However, this possible bias in responses due to prevailing economic conditions at the time of survey was partially addressed in two ways. First, we asked only few questions with reference to any specific year, most of the questions were asked about general pricing behavior without specification of time. Furthermore, for questions that did involve time, enumerators probed the re-

[21]We have already mentioned that during the survey, inflation was 4-6% above its historical average of 8% and continues to persist at higher level.

spondents about whether their responses would have been different in 2007 and 2008.[22] Second, it is reasonable to expect lower price-stickiness in a country with such a high steady state inflation of 8%. This assertion is further supported by pricing surveys in other countries.[23]

Therefore, most of the results presented in this paper should also apply to normal times. Nevertheless, a fool-proof method of meeting this concern would be to conduct a panel survey in normal times which the central bank is committed to do in the future.

Another caveat of this study is the population frame of the services sector. The frame for the services sector was manually constructed using a database[24] that lacks information on number of employees and standard economic classification code, but has data on paid up capital.

We excluded firms that have not reported in last ten years. By excluding firms that have not reported recently, we probably missed out on some live firms. However, it would not matter if the missing services sector firms are distributed evenly across different economic activities.

Furthermore, we only selected firms with paid up capital of more than Rs.2,000,000. This might have introduced a bias for larger services sector firms. However, note that given our small sample size for services sector it would have been almost impossible to make statistically significant inferences for a very large population of small firms.

Finally, during our survey another group of researchers came up with a similar study for Pakistan. Shahid, Satti and Saghir (2010) conducted the survey for price setting behavior for only four cities of the province of Punjab. However, their study, had many shortcomings such as lack of national rep-

[22] We found little difference in responses between different years.

[23] Canada, UK and Turkey displaying higher inflation rates at the time of their surveys also reported higher frequency of price change.

[24] Securities and Exchange Commission of Pakistan's listing of registered firms

resentation, no proper customization and ignoring the existence of informal economy. However, we take this study as a pilot for our survey in Punjab and find that most of our results were consistent with Shahid et al (2010).

## 2.9 Conclusion

We presented results of 1189 structured interviews of formal sector firms in the manufacturing and services sectors in the provinces of Punjab and Sindh. The sample for the manufacturing sector is fully representative while the services sector, which is 14% of the total sample, is less so.

We find that although imperfect competition is a good representation of firm's behavior, frequency of price changes are high enough to question the role of nominal rigidities in explaining business cycle fluctuations in Pakistan. The exchange rate is more important than financial costs in price-setting and generally cost shocks matter more than demand shocks. Most of the firms in our sample use some kind of backward-looking information, while making pricing decisions.

Also, majority of formal firms interact with firms in the informal sector, however manufacturing sector have a higher level of interaction with the informal sector than the services sector. Finally, formal firms with greater interaction with the informal sector firms tend to increase their prices less frequently.

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# 2.A Chapter 2 Comparative Analysis

TABLE A1

*Macroeconomic Data*

| | *Pakistan* [a,b] | *Euro Area* [c] | *United States* [c] |
|---|---|---|---|
| Survey period | Dec 2009 - June 2011 | Feb 2003 - Nov 2004 | Apr 1990 - Mar 1992 |
| Data reference period | 2009 - 2010 | 2003 - 2004 | 1990 - 1992 |
| Inflation (GDP Deflator) | 11.9 / 18.8 [a] | 1.9 / 2.1 | 2.3 / 3.9 |
| Real GDP growth | 2.4 / 3.8 [a] | 0.6 / 1.7 | - 0.2 / 3.3 |
| Unemployment rate | 5.5 / 5.6 [a] | 8.8 / 8.9 | 5.6 / 7.5 |
| Exchange rate variation | -0.6 / -4.8 [b] | 11.3 / 3.4 | -0.9 / -5.7 |

*Source:* Pakistan Economic Survey 2010-11 & SBP Statistics Department & Fabiani et.al (2007)

*a:* Pakistan Economic Survey 2010-11, Government of Pakistan, Ministry of Finance

*b:* Author's calculation on exchange rate data from SBP.

*c:* Fabiani et al.(2007), pp 188

TABLE A2

*The Individual Surveys*

| | *Pakistan* | *Euro Area* [a] | *United States* [a] |
|---|---|---|---|
| Main source | Author's calculations | Fabiani et.al (2008) | Blinder et.al (1998) |
| Form of survey | Structured face- -to-face interviews | mailed questionnaires, phone, face-to-face, internet | Structured face-to-face interviews |
| Date or timing | Dec 2009 - June 2011 | Feb 2003 - Nov 2004 | Apr 1990 - Mar 1992 |
| Conducted by | Central Bank (SBP) & 2 Statistical Agencies (BOS Punjab) (BOS Sindh) | 4 National Central Banks & (BE, FR, LU, PT) 5 external agencies (DE, ES, IT, NL, AT) | Princeton graduate students |
| Firms contacted | 1,189 [b] | 24,248 | 350 |
| Firms interviewed | 2,100 [b] | 11,039 | 200 |
| Response rate | 57% [b] | 46% | 61% |
| Random sample | Yes: sample was stratified according to size & economic sector | No | Yes |
| Sectoral coverage | Manufacturing 86% Services 14% | Manufacturing 62% Services 21% Trade 13% Others 4% | Manufacturing 35% Services 27% Trade 18% Others 20% |
| Representative of the firm size distribution | Yes | No | No |
| Reference price | Main product | Main product | Not specified |

*Source:* Author's calculations & Fabiani et.al (2007)

*a:* Fabiani et al.(2007), pp 186-187

*b:* This number is provisional, it will be updated after all the surveys have been completed.

## 2.B Chapter 2 Post-Stratification and Weighting Scheme

Following Kwapil et al (2005) and Martins (2005) for Austria and Portugal, manufacturing sector weights were redefined to sub-sector of economic activity and size of firm. The weight $w_h$ represents the weights of hth stratum

$$w_h = \frac{\frac{P_h}{P}}{\frac{S_h}{S}} \tag{2.4}$$

where, $P_h$ is the number of employees in stratum $h$ in the population, $P$ is the total number of employees in the population. Similarly, $S_h$ is the number of employees in the firms interviewed in stratum $h$ and $S$ is total number of employees for all the firms in our sample.

For services sector, the information set available is not enough to justify post-stratification for firm-size on the basis of employment. However, we have information on paid-up capital. We use this information to post stratify for firm size and therefore allowing us to treat both selected economic sectors consistently. We divided firms in services sector on the basis of paid-up capital (in local currency) as small, medium and large firms according to $<$ Rs.15,000,000, 15,000,000-50,000,000 and $>$ 50,000,000 respectively.[25] The responses for the services sector in this paper are reported after post stratification, the weight of hth stratum is given by

$$w_h = \frac{\frac{C_h}{C}}{\frac{o_h}{o}} \tag{2.5}$$

where, $C_h$ is the paid-up capital of firms in stratum $h$, $C$ is the total paid-up capital of population frame of firms in services sector. Similarly, $o_h$ is the

[25]We can draw comfort from the fact that this categorization has a correlation coefficient of 0.5 with employment categorization used earlier on the basis of employment data we collected from the 'surveyed' sample.

paid-up capital in the firms interviewed in stratum $h$ and $o$ is total paid-up capital of all the firms interviewed.

The above individual weighting schemes for the manufacturing and services sectors do not account for their share in the economy. This means that to make inferences about price-setting for the aggregate economy, especially for those results[26] that can be aggregated, we must reweigh the results on the basis of economy-wide sector weights in Table 2.

Therefore, we post-stratified the data of manufacturing and services sectors by their respective weights in the total GDP, these results are reported under the nomenclature of 'total' in our analysis.

[26]Note that not at all questions can be aggregated since they may simply be sector specific . For example costs breakdown in manufacturing sector are naturally different from that of services sector and therefore can not be aggregated. Similarly, cost specific shocks and their ramifications for pricing can not aggregated in a sensible way.

# 2.C Chapter 2 Reasons for Price Stickiness

Table 7B:

*Reasons for Price Stickiness*

| | *Manufacturing* | | | | *Services* | | |
|---|---|---|---|---|---|---|---|
| *Theories* | *Mean*† | *p-val** | *Imp.*‡ | *Theories* | *Mean*† | *p-val** | *Imp.*‡ |
| Coordination Failure | 3.2 | 0.00 | 84 | Coordination Failure | 3.1 | 0.00 | 79 |
| Temporary Shocks | 2.5 | 0.00 | 55 | Risking Customer Relations | 2.2 | 0.23 | 41 |
| Risking Customer Relations | 2.3 | 0.89 | 46 | Explicit Contracts | 2.1 | 0.17 | 44 |
| Procyclical Elasticities | 2.3 | 0.03 | 44 | Temporary Shocks | 2.0 | 0.66 | 39 |
| Habit Formation | 2.2 | 0.89 | 40 | Procyclical Elasticities | 2.0 | 0.38 | 40 |
| Constant Unit Cost | 2.2 | 0.20 | 40 | Habit Formation | 2.0 | 0.00 | 31 |
| Delivery Time | 2.1 | 0.07 | 41 | Thick Markets | 1.8 | 0.01 | 29 |
| External Financing | 2.0 | 0.00 | 39 | Constant Unit Cost | 1.6 | 0.53 | 22 |
| Using Inventories | 1.9 | 0.84 | 30 | Informal Sector Coordination Failure | 1.6 | 0.42 | 22 |
| Explicit Contracts | 1.9 | 0.88 | 31 | Implicit Contracts | 1.5 | 0.57 | 19 |
| Thick Markets | 1.8 | 0.49 | 27 | External Financing | 1.5 | 0.09 | 19 |
| Informal Sector Coordination Failure | 1.8 | 0.00 | 28 | Costly Information Gathering | 1.4 | 0.54 | 12 |
| Implicit Contracts | 1.6 | 0.00 | 22 | Menu Costs | 1.4 | 0.02 | 5 |
| Costly Information Gathering | 1.4 | 0.00 | 13 | Delivery Time | 1.3 | 0.00 | 12 |
| Menu Costs | 1.3 | 0.00 | 8 | Using Inventories | 1.2 | 0.00 | 6 |

*Source:* Author's calculations

†: 1, 2, 3 and 4 denote unimportant, of minor importance, important, and very important

*: This p-value refers to the null hypothesis that theory's mean score is equal to the theory

*: ranked below

‡: Percentage of firms rating the theory as important or very important.

## 2.D Chapter 2 Tables

TABLE 1

*The Sample*

| | *Manufacturing* | *Services* | *Total* |
|---|---|---|---|
| Small | 573 | 103 | 676 |
| Medium | 291 | 40 | 331 |
| Large | 161 | 21 | 182 |
| Sindh Representation | 28% | 37% | 29% |
| Total | 1025 | 164 | 1189 |

*Source:* Author's calculations

TABLE 2

*The Overall Representation (percentages)*

| | *Manufacturing* | *Services* | *Total* |
|---|---|---|---|
| Pakistan GDP 2009-10 | 18.6 | 52.4 | 71.0 |
| GDP represented by our sample† | 12.2 | 13-15 | 25.2-27 |
| Sector distribution in our sample | 86 | 14 | 100 |

*Source:* Author's calculations & Pakistan Economic Survey 2010-11

†: This percentage is used for reweighting sector estimates

TABLE 3 [a]

*Market and Competition of the Main Product (weighted percentages)*

| | *Manufacturing* | *Services* | *Euro Area* † |
|---|---|---|---|
| *Reference Market* | | | |
| i. International | 5 | 14 | 27 [b] |
| ii. Local Market (City and Surrounding Areas) | 33 | 37 | |
| iii. National Market excluding (ii). | 62 | 49 | |
| iv. ii+iii | 95 | 86 | 73 [b] |
| *% of Turnover in Pakistan* | | | |
| 41-60 | 16 | 6 | |
| 61-80 | 29 | 7 | |
| 81-100 | 45 | 74 | |
| *Market Share* | | | |
| Top Firm | 5 | 11 | |
| Top Four Firms | 13 | 22 | |
| Top Ten Firms | 17 | 22 | |
| Not among the Top 10 Firms | 37 | 41 | |
| *Type of Main Customer and long-term relationship* | | | |
| Other Firms | 79 | 34 | 75 [b] |
| Customers | 20 | 58 | 21 [b] |
| Public Sector | 2 | 8 | 3 [b] |
| *Firm-Customer relationships* | | | |
| Long term | 56 | 36 | 70 [b] |
| Occasional | 44 | 64 | 30 [b] |
| *Perceived Degree of Competition* | | | |
| Very High | 47 | 56 | 26.2 [c] |
| High | 26 | 24 | 35.2 [c] |
| Medium | 22 | 15 | 21.5 [c] |
| Weak | 2 | 3 | 17.1 [c] |

*Source:* Author's calculations & Fabiani et al.(2007).

†: Weighted Average by country's GDP in Fabiani et al. (2007).

*a:* Rescaled figures excluding non-responses

*b:* Fabiani et al.(2007), pp 33

*c:* Fabiani et al.(2007), pp 202

TABLE 4 [a]

*Price Rules (percentages)*

| | *Pakistan* | *Euro Area* |
|---|---|---|
| *Markup* † | | |
| Manufacturing | 34 | 56 [b] |
| Services | 63 | 46 [b] |
| Total | 47 | 54 [c] |
| *Competitors Price* | | |
| Manufacturing | 44 | 27 [b] |
| Services | 29 | 24 [b] |
| Total | 37 | 27 [c] |
| *Other* ‡ | | |
| Manufacturing | 22 | 17 [b] |
| Services | 8 | 31 [b] |
| Total | 16 | 18 [c] |

*Source:* Author's calculations & Fabiani et al.(2005).

*a:* Rescaled figures excluding non-responses

*b:* Fabiani et al.(2005), pp 41

*c:* Fabiani et al.(2005), pp 14

†: Include constant, variable and customer markups.

‡: Include prices determined by association and the government.

TABLE 5 [a]

*Price Assessments (percentages)*

| | *Pakistan* | *Euro Area* [b] | *US* [b] |
|---|---|---|---|
| *Purely Time-Dependent* | | | |
| Manufacturing | 54 | | |
| Services | 47 | | |
| Total | 51 | 34 | 60 |
| *Purely State-Dependent* | | | |
| Manufacturing | 27 | | |
| Services | 21 | | |
| Total | 24 | 20 | 30 |
| *Generally Time-Dependent but also Event Based* | | | |
| Manufacturing | 11 | | |
| Services | 7 | | |
| Total | 9 | 46 | 10 |
| *Purely Time-Dependent* | | | |
| Small | 50 | | |
| Medium | 52 | | |
| Large | 57 | | |

*Source:* Author's calculations; Fabiani et al.(2007) & Blinder et al.(1998).

*a:* Rescaled figures excluding non-responses

*b:* Fabiani et al.(2007), pp 192

TABLE 6

*Actual Price Changes*

| | *Pakistan* | *Euro Area* | *US* |
|---|---|---|---|
| Median Number of Price Changes in a Year | 3 | 1 [a] | 1.4 [d] |
| Implied Median Spell of Price Change in Months † | 4 | 12 | 8.6 |
| % of Firms that Review their Prices With a Month | 73 | 26 [b] | 25.6 [e] |
| % of Firms that Change Price Within a Month | 23.9 | 16 [c] | 20.9 [d] |
| Quarterly Calvo Probabilities using Median Duration ‡ | 0.25 | 0.75 | 0.65 |

*Source:* Author's calculations; Fabiani et al.(2007) & Blinder et al.(1998).

†: This is ratio of 12 and median of number of price changes in a year.

‡: The probability that firms do not re-optimize the prices they charge during a quarter

*a:* Fabiani et al.(2007), pp 191

*b:* Fabiani et al.(2007), pp 36

*c:* Fabiani et al.(2007), pp 223

*d:* Authors calculation based on results in Blinder et al.(1998), pp 84

*e:* Authors calculation based on results in Blinder et al.(1998), pp 90

TABLE 6A

*Median Number of Price Changes in a Year*

| | | *Pakistan* |
|---|---|---|
| Sector | Manufacturing | 6 |
| | Services | 2 |
| Firm Size | Small | 3 |
| | Medium | 2 |
| | Large | 3 |

*Source:* Author's calculation

TABLE 6B

*Median Number of Downward Price Changes in 5 Years*

| | *Pakistan* |
|---|---|
| Manufacturing | 5 |
| Services | 1 |
| Total | 2 |

*Source:* Author's calculation

TABLE 7A [a]

*Ranking Reasons for Price Stickiness*

| *Theories* | *Description* | *Pakistan* | | *Europe* † | *US* ‡ |
|---|---|---|---|---|---|
| | | *Manufac* | *Services* | | |
| Coordination Failure | Firms watch what other firms will do first | 1 | 1 | 4 | 1 |
| Temporary Shocks | Firms avoid price changes if they perceive a shock (demand or supply) to be transitory | 2 | 4 | 7 | |
| Risking Customer Relations | Customer might take the price change as exploitative | 3 | 2 | | 1 * |
| Procyclical Elasticities | When times are good customers become more price sensitive | 4 | 5 | | 6 |
| Habit Formation | When times are good share of non-habitual customers with higher price elasticities increases | 5 | 6 | | |

*Source:* Author's calculations; Fabiani et al.(2007) & Blinder et al.(1998).

a : It is important to note that we can't make a direct comparison between rankings from different countries as the number of theories and style of asking this question is different for different surveys. However, this comparison is still useful to get a general idea.

†: Unweighted average of national rankings; Fabiani et al.(2007), pp 196

‡: Authors calculation based on results in Blinder et al.(1998), pp 110

∗: In US, firms were asked out of freewill to cite what in general stopped them from changing prices and the largest majority said customer's antagonism.

TABLE 8

*The Importance of Factors Driving Price Changes and Lags of Adjustment (mean score†)*

| | *Pakistan* | | | | | | *Euro Area* [a] | |
|---|---|---|---|---|---|---|---|---|
| | *Manufacturing* | | | *Services* | | | *Overall* | |
| | ↑† | ↓† | p-value‡ | ↑† | ↓† | p-value‡ | ↑† | ↓† |
| Raw Material Cost | 3.7* | 3.4* | 0.00 | 1.9*** | 1.8**** | 0.00 | 3.1 | 2.6 |
| Energy Cost | 3.1* | 2.9** | 0.00 | 2.5*** | 2.1**** | 0.00 | | |
| Competitor's Price | 2.9* | 2.9* | 0.03 | 2.5*** | 2.3*** | 0.00 | 2.4 | 2.8 |
| Exchange Rate | 2.5** | 2.4** | 0.00 | 2.8** | 2.6*** | 0.00 | | |
| Demand Changes | 2.4*** | 2.6** | 0.00 | 2.1*** | 2.0**** | 0.24 | | |
| General Price Level | 2.2** | 2.4** | 0.18 | 1.9*** | 1.6**** | 0.00 | | |
| Labor Cost | 2.2*** | 1.9*** | 0.00 | 2.5*** | 2.1**** | 0.00 | 3.0 | 2.1 |
| Financial Cost | 2.2*** | 2.1*** | 0.00 | 1.7**** | 1.6**** | 0.00 | 2.2 | 1.9 |
| Labor Productivity | 1.9*** | 1.9*** | 0.05 | 1.4**** | 1.3**** | 0.92 | | |

*Source:* Author's calculations & Fabiani et al.(2007)

†: 1, 2, 3 and 4 denote unimportant, of minor importance, important and very important

asterisk denote *incorporated within three months, **incorporated within six months,

***incorporated within nine months, **** incorporated within a year.

‡:Refers to null hypothesis that the mean lag of price adjustment for a given factor for

‡: price increase is equal to price decrease.

↑ and ↓: Refer to increase and decrease in price respectively.

TABLE 9

*Breakdown of Total Cost in 2009 (average of percentages)*

| | *Manufacturing* | *Services* | *Total* |
|---|---|---|---|
| Local Raw Material Cost | 60 | 8 | 39 |
| Imported Raw Material Cost | 10 | 8 | 9 |
| Energy | 13 | 12 | 13 |
| Labor | 11 | 40 | 23 |
| Other | 6 | 32 | 17 |

*Source:* Author's calculations

TABLE 10 [a]

*Information Type (percentages)*

| | *Manufacturing* | *Services* | *Total* | *Euro Area* |
|---|---|---|---|---|
| Historical Data | 27 | 22 | 25 | 34 [b] |
| Forecast | 29 | 30 | 29 | 48 [b] |
| An Average of Past and Future | 44 | 48 | 46 | |

*Source:* Author's calculations & Fabiani et al.(2007)

*a:* Rescaled figures excluding non-responses

*b:* Fabiani et al.(2007), pp 37

TABLE 11

*Why be part of the Formal Sector? (mean score)*

| | *Manufacturing* † | *Services* † | *Total* † | *Importance* ‡ |
|---|---|---|---|---|
| Economies of Scale | 3.4 | 3.3 | 3.4 | 91% |
| Customer Preferences | 3.2 | 3.4 | 3.3 | 87% |
| Market Power | 2.8 | 2.9 | 2.8 | 79% |
| Favorable Government Policies | 2.6 | 2.7 | 2.7 | 66% |
| Access to Bank Credit | 2.4 | 2.8 | 2.5 | 67% |
| Access to International Market | 1.8 | 2.8 | 2.1 | 48% |

*Source:* Author's calculations

†: 1, 2, 3 and 4 denote unimportant, of minor importance, important and very important

‡: Percentage of firms rating the factor as important or very important.

TABLE 12

*Concerns with Staying in the Formal Sector (mean scores)*

| | *Manufacturing* † | *Services* † | *Total* † | *Importance* ‡ |
|---|---|---|---|---|
| Product Standardization | 3.2 | 2.6 | 3.0 | 74% |
| Entry-Exit is Costly | 2.9 | 2.5 | 2.8 | 62% |
| Discriminatory Energy Charges | 3.1 | 2.3 | 2.8 | 62% |
| Labor Regulations | 2.9 | 2.2 | 2.6 | 63% |
| EOBI Contributions | 2.8 | 2.2 | 2.6 | 58% |
| Bureaucratic Hurdles | 2.5 | 2.0 | 2.3 | 43% |
| Price Regulations | 2.4 | 2.0 | 2.2 | 46% |
| Rental Charges | 2.0 | 1.8 | 1.9 | 30% |

*Source:* Author's calculations

†: 1, 2, 3 and 4 denote unimportant, of minor importance, important and very important

‡: Percentage of firms rating the factor as important or very important.

∗ Employment and Old Age Benefit

TABLE 13

*Linkages with the Informal sector (percentages)*

| | *Manufacturing* | *Services* | *Total* | *Small* | *Medium* | *Large* |
|---|---|---|---|---|---|---|
| No interaction | 41.5 | 77.8 | 56.3 | 56.3 | 56.1 | 57.4 |
| Demand Only | 32.1 | 16.0 | 25.5 | 24.2 | 23.2 | 37.4 |
| Supply Only | 7.7 | 3.8 | 6.20 | 6.9 | 6.1 | 0.9 |
| Demand and Supply | 58.5 | 22.2 | 43.7 | 43.7 | 43.9 | 42.6 |
| Market Share | 24.8 | 30.0 | 26.2 | | | |
| Share in Total Cost | 35.8 | 15.3 | 30.2 | | | |

*Source:* Author's calculations

TABLE 14

*Factors Contributing to the Existence of the Informal Economy (mean scores)*

| | *Manufacturing* † | *Services* † | *Total* † | *Importance* ‡ |
|---|---|---|---|---|
| Lack of Taxes | 3.4 | 3.1 | 3.3 | 84% |
| Tax Compliance/Enforcement | 3.1 | 2.8 | 3.0 | 82% |
| Simple Production Process | 3.1 | 2.4 | 2.9 | 74% |
| Costless Entry and Exit | 3.0 | 2.4 | 2.8 | 67% |
| Low Labor Cost | 2.9 | 2.7 | 2.8 | 68% |
| Corruption | 3.0 | 2.2 | 2.7 | 62% |
| Lack of Resources | 2.8 | 2.3 | 2.6 | 61% |

*Source:* Author's calculations

†: 1, 2, 3 and 4 denote unimportant, of minor importance, important and very important

‡: Percentage of firms rating the factor as important or very important.

# Chapter 3

# Modeling Business Cycles in Pakistan: A First Step

## 3.1 Introduction

What are the stylized facts of the Pakistani economy? Has the nature of the economy shifted with significant changes in the social and political landscape of the country? What is the current nature of the Pakistani economy (last few decades)? What drives short and medium run fluctuations in the economy? Is the Pakistani economy driven by technology shocks as advocated by the well known RBC literature or is it driven by external factors?

In order to answer these important questions, I first try to establish the nature and structure of Pakistani economy over the last 5 decades, focusing mainly on the period of 1981-2010. After the initial look into salient features of the economy, this paper also tries to establish some 'stylized facts' for the Pakistani economy. In addition, I find that these 'stylized facts' of the economy have been changing over the last few decades. This lead me to focus on the relatively contemporary period of 1981-2010 for an in-depth analysis of short-

run fluctuations. By short run fluctuations, I mean that the empirical analysis in this paper uses the conventional frequencies for isolating data from its trend to study business cycles. For completeness, I also examine data in terms of growth. In addition, we also break down the data decade by decade to get a clearer picture of changing nature of the cyclical fluctuations in the economy.

Furthermore, I evaluate the fit of the Pakistani macroeconomic data with a simple Real Business Cycles model for the 1981-2010 period. I find that a simple RBC model does a good job of matching some of the relevant moments from the data. However, it fails to account for the increased relative volatility of consumption and investment as shown by the data.

In order to further improve the fit, I introduce an augmented RBC model, with an exogenous FDI shock as the main innovation. I find that the augmented RBC model performs better than the simple RBC model for some of the moments but more importantly delivers the increased relative volatility of consumption and investment. However, the augmented model does poorly on the absolute magnitude of volatilities across the board.

Real Business Cycles based models are now being widely used for policy analysis and the study of optimal fiscal and monetary policy in most developed countries. In the last few years, emerging economies have also started exploring the use of RBC type models in their policy making activities.

However, we still know very little about business cycles in developing countries. Furthermore, existing real business cycles models for developing countries (Garcia-Cicco (2010), Aguiar & Gopinath (2007)) have been mainly focused on South American countries. They seem to suggest that cycles in different developing economies are similar and can be explained in the same manner. Gopinath (2007) in her paper suggested that business cycles for developing economies can be explained by a simple RBC model with the addition

of a stationary trend productivity shock on top of the traditional exogenous technology shock. However, recent work by Garcia-Cicco et al (2010) challenges the main result of the earlier work of Gopinath & Gertler (2007) and reports that for both Chile and Argentina a simple RBC model with a trend stationary technology shock fails to explain their respective business cycles.

It is a well known fact that not all emerging economies are the same and therefore it should be no surprise that the nature and behaviour of their economies differ from each other. These economic differences between developing countries should be addressed rigorously to completely understand the business cycles of any particular developing country. This line of reasoning has recently become quite popular, as the last few years has seen a rapid increase in the literature related to country-specific business cycles models for different developing countries.

Unfortunately, even with the recent surge in the literature related to business cycles in developing economies, there are not many business cycle models for South Asian countries. To the best of the author's knowledge, only work for India has been undertaken for both establishing the business cycle facts of the economy as well as evaluating the fit of a typical RBC model to explain the 'stylized facts' of a South Asian economy. This project is the first of its kind to explore the short-run fluctuations of the Pakistani economy as well as checking the ability of the RBC model setup in matching the empirical moments for the relevant macroeconomic variables (Output, Consumption & Investment).

The main reason for the dearth of economic research relating to business cycles of developing countries is the lack of availability of relevant time series data at appropriate frequency. Therefore, anyone interested in studying the cyclical fluctuations of a country like Pakistan has to deal with data availability

and consistency issues even for the most basic macroeconomic variables.

There is no quarterly data available for the relevant macroeconomic series of Pakistan. The main variables of interest such as output, private consumption, government expenditures, investment, exports and imports[1] are only available at an annual frequency. However, even with annual data there are still issues of consistency from different sources. In this scenario, it is hard to even establish the 'stylized facts' of the economy. In this paper, I mainly use the 'annual' data from Pakistani sources such as the Pakistan Bureau of Statistics, the Government of Pakistan and the State Bank of Pakistan. However, for some of the analysis related to business cycles I also use data from IMF's International Financial Statistics database.

In addition, on the calibration front there are no agreed upon values for even the most basic parameters such as discount rate $\beta$ or depreciation rate $\delta$. There is also a severe lack of understanding and knowledge regarding the micro-foundations of the economy. This is being partially addressed by the surveys being conducted by the State Bank of Pakistan in the labour, product and credit markets.

The rest of the paper is organized as follows. Section 2 presents some structural facts of the economy as well as the basic 'stylized facts' of economic fluctuations' in Pakistan. Because this is the first exercise of its kind, the reader is warned that Section 2 is long. Readers wishing to skip details are invited to proceed to Section 2.5 for a summary of the various stylized facts we have uncovered. Section 3 presents our model. Section 4 presents the calibration, the impulse response functions and evaluates the model's ability to capture the basic features of the data. The last section concludes.

[1]Exports and Imports are the exceptions as data for them is available at monthly frequency

## 3.2 Empirical Facts of Pakistani Economy

In this section I first present some structural facts on the Pakistani economy in general and how the nature of the economy has shifted over the last 50 years. After discussing the structure of the economy I pay attention to the long run behaviour of macroeconomic variables of interest. In order to further explore the link between different variables, I also undertake a thorough analysis using contemporaneous and dynamic correlations. Finally, I take a look at the growth rate and HP filtered cyclical series of relevant variables to establish some 'stylized facts' of short run economic fluctuations in Pakistan.

### 3.2.1 Some Basic Structural Facts

Pakistan has been an agrarian economy from the start of its existence. The agriculture sector accounted for more than 1/2 of total output in 1950. However, over time the share of agriculture in total production has been steadily declining and was a little more than 1/5 of the total Output in 2010.

On the other hand, Figure 1 shows that the decline in the share of agriculture in production has been accompanied by an increase in the share of the services sector in total output. The share of the services sector in production has increased to more than 1/2 of overall production in the economy and has been for most part of the last few decades. Furthermore, the share of industry in production has increased almost 3 fold since 1950. The industrial sector now accounts for a little less than 3/10 of total output. However, the industrial sector has stagnated over the last three decades.

Figure 1, points out that the nature of the Pakistani economy has shifted from being agrarian to more service oriented. However, limiting attention only to sectoral shares of output can be misleading for fully understanding the

changing nature and evolution of the Pakistani economy.

Even though the contribution of the agriculture sector has declined significantly on the production side, the lower two panels of Figure 1 point out that in real terms the Pakistani economy is still very agrarian, as almost 1/2 of all employed persons in the country are still working in the agriculture sector.

This is puzzling as there is a difference in the pattern of sectoral breakdown of employment and production. It is true that the sectoral share of employed persons has moved in the same direction as the sectoral share of output for both the agriculture and services sector. On the other hand, the share of employed persons working in the industrial sector has remained more or less the same over the last few decades.

Table 1 shows that even though the sectoral share of agriculture has declined for both output and employment, the decline in the share of output is steeper than the decrease in the share of employed persons for the agriculture sector.

This puzzle can be addressed in several ways. First, a possible increase in labour productivity of the services and industry sector, the latter to a smaller extent, as well as a possible productivity slowdown in the agriculture sector. In other words, almost 1/2 of Pakistani labour force (employed persons in agriculture) is currently producing around 1/5 of its output. Second, the presence of a large informal sector, not part of our current analysis, can not be ignored. The informal sector remains a big part of the agricultural sector and available statistics undermine its dynamics and size.

### 3.2.2 Some Long-run Ratios

After looking at some structural facts of the economy, lets consider long run behaviour of macroeconomic variables. In the business cycle literature, it is

the usual practice to look at the long run ratio of consumption to output, investment to output ratio, government consumption to output as well as net exports to output ratio before studying the short run fluctuations.

**Aggregate Investment & Other Disaggregated Components of Aggregate Investment**

Lets first consider the long run behaviour of investment over the last few decades. Investment is widely considered the main driver of long run growth of any economy. In Figure 2A, we can see that investment to output ratio has been moving between 0.10 to 0.22 over the last five decades. However, for the period from 1981-2010 the ratio has fluctuated between a high of 0.21 in 2008 and a low of around 0.14 in 1999 and 2010 respectively. Another interesting observation from the second panel of Figure 2A is that the volatility of the investment to output ratio has become much more pronounced over the last 10-15 years.

Due to the previously mentioned importance of investment, the rest of the panels of Figure 2A help us in taking a detailed look at different components of aggregate investment in order to better understand the source of volatility in the investment to output ratio. The rest of the graphs in Figure 2A are presented as a share of given component of total investment in total investment (e.g share of private investment in total investment). This helps us in clearly identifying the relevant patterns in different disaggregated components of investment.

After breaking down aggregate investment into public and private investment we can see that the share of public investment in total investment has been declining from mid to late 80's until very recently. Furthermore, from 1990 onwards the share of private investment has overtaken the share of public

investment and was more than twice the size of public investment (0.72 vs 0.28) in 2010. This shift over the last 20 years or so can be a result of changes in the financial sector due to financial sector reforms starting in late 80's and early 90's. Finally, this significant gap between the share of private and public sector investment seems to be stabilizing over the last few years. This bodes well for the idea that Pakistani economy is moving towards a more market driven economy with a relatively smaller role of government in domestic investment and minimal interference in financial markets.

Another interesting observation from Figure 2A about the investment dynamics of Pakistan is the fact that starting from last decade the decline in share of public investment in overall investment has been accompanied by the increase in the share of Foreign Direct Investment (FDI) in overall investment. Not surprisingly, this surge in FDI in Pakistan is strongest for the most part of the last decade (2001-2008) where there was a global boom in FDI in developing countries in general and South Asian countries in particular. However, just like for other countries FDI inflows to Pakistan have dried up since the great recession and financial crisis starting in 2008 The share of FDI in total investment has declined by almost 50% in the last three years.

For Pakistan, the share of FDI in total investment reached a peak value of 0.17 in 2007 before declining in the last few years. This further emphasizes the importance of foreign investment in complementing domestic private investment of the country which in turn is mainly responsible for the economic growth. In order to further evaluate this claim, I look closely at the link between domestic and foreign investment in the next sub-section.

**Private Consumption, Government Consumption, Exports & Imports**

After investigating the long run behaviour of aggregate investment and its various disaggregated components, I turn my attention to long run behaviour of other macroeconomic variables. In the first two panels of Figure 2B, we present the long run behaviour of private consumption in Pakistan. The ratio of private consumption to output has fluctuated considerably between 0.68 and 0.84 during the period of 1960-2010. Hence, it is clear that private consumption has always been the largest component of aggregate output for the Pakistani economy.

However, it is important to note that the significant role of private consumption from the data comes with a caveat. The data for private consumption in Pakistan is not collected or gathered but instead private consumption is computed as a residual from the income identity equation. Furthermore, Malik (2011) using Pakistani data recently found that private consumption data from national accounts is significantly different from the consumption data gathered from household surveys.

The long run ratio of private consumption to output is volatile and it shows some cyclical behaviour. Over the period of 1981-2010, the share of private consumption in output declined initially reaching the lowest value of 0.68 in 1991. However, since reaching the lowest value of 0.68 the share has had an increasing trend with a value of 0.82 in 2010.

After analysing the long-run behaviour of private consumption next up is the long-run behaviour of government consumption. The ratio of government consumption to output also exhibits significant volatility with values ranging between 0.08 to 0.17. In particular, the last decade shows a number of episodes of upward and downward movement in the ratio of government consumption to

output. The share of government consumption in output also exhibits cyclical patterns rather than a stable long run value.

Moving on to trade related variables of exports and imports, I consider their long run behaviour over the last five decades. In Figure 2B, there is a significant jump upwards in both exports to output and imports to output ratio in early to mid 70's. The value of exports to output ratio almost doubled between 1972 and 1973, similarly the value of imports to output ratio also increased significantly between 1972 and 1973. Over the last three decades (1981-2010), the share of exports in output has fluctuated between 0.10 and 0.17. On the other hand, imports to output ratio has been between 0.14 and 0.24.

The behaviour of exports to output and imports to output ratio over the last three decades is in line with other evidence suggesting that Pakistan over the last 30 years has started behaving more and more like a small open economy. This is further supported by the fact that more than 1/3 of output was due to trade (exports + imports) on average over the period from 1981-2010.

Before moving on to other empirical evidence, it is important to establish the linkages between different macroeconomic variables and business cycle features. Let's revisit the claim made earlier that the economy has started behaving differently over the last three decades as opposed to the earlier period. Looking at Table 2, the differences in magnitude of these long run ratios as measured by mean, median, and volatility as measured by coefficient of variation, and another measure of volatility (std.dev/median) are obvious.

These differences are less pronounced for the magnitude of some long run ratios. The absolute value of different long run ratios are similar for the two periods of 1960-1980 and 1981-2010 except for the trade related ratios of exports to output and imports to output. The value of both trade variables

has increased significantly as a share of overall output. For the exports to output ratio the average value was 0.09 for the earlier period and 0.14 for the latter period. Similarly, the imports to output ratio on average was 0.15 for the period spanning 1960-1980 and the average was 0.20 for the period between 1981-2010. On the other hand, the average of private consumption to output ratio has decreased slightly from 0.79 to 0.75 and investment to output ratio has increased from 0.15 to 0.17 respectively. Finally, the value of government consumption to output on average has remained almost same throughout the last five decades at around 0.11.

The main findings from Table 2 are the significant changes in volatility measure of coefficient of variation between the two periods for almost all of the variables. There is a significant decrease in the volatility of both exports to output ratio and imports to output ratio from the period of 1960-1980 to the period of 1981-2010. The coefficient of variation for both investment to output ratio and FDI to output ratio have also reduced significantly for the latter period as compared to the former period. Interestingly, government consumption to output ratio is the only long run ratio with a significantly increased volatility during the 1981-2010 period as oppose to the earlier period of 1960-1980. The volatility of private consumption to output ratio as measured by the coefficient of variation is very similar for the two periods being compared. However, as mentioned before, any analysis involving private consumption should be interpreted cautiously due to the residual nature of the private consumption data.

After the brief comparison of the two periods of 1960-1980 and 1981-2010 based on the magnitude and volatility of long run ratios and our previous findings about the structure of the economy, I will focus on the period from 1981-2010 for the rest of the empirical analysis.

### 3.2.3 Correlations & Dynamic Correlations

In order to better understand the relationship between different macroeconomic variables, I look at contemporaneous correlations and dynamic correlations in this section. In particular, I want to empirically establish the linkages between output and aggregate investment, FDI, private consumption, government consumption, exports and imports. This exercise will help identify the macroeconomic variables to focus on in order to develop a better understanding of the economy and to develop a relevant model of business cycle fluctuations of Pakistan. For this part of the paper, I consider both the growth rate and HP filtered data for the period of 1981-2010 and decade by decade as well.

#### Growth Rate

#### Aggregate Investment & Other Disaggregated Components of Aggregate Investment

First of all, I look at investment related variables as investment and private consumption are both significantly correlated with output according to Table 3B & Table 4B for both growth rate and HP filtered series.

Table 3A describes the linkages between the growth rate of different disaggregated component of aggregate investment such as private investment, all public investment[2], public investment, government investment, private domestic investment and foreign direct investment and growth rate of output.

Over the period of 1982-2010, the growth rate of aggregate investment, all public investment, public investment, government investment and foreign direct investment are all significantly positively related with output growth. The Table also shows that the growth rate of aggregate investment is most

[2]It is the sum of public and government investment. The former comprises of investments by public sector enterprises and the latter refers to investments by federal and provincial governments in different projects

significantly correlated with growth of private investment, which in turn is strongly correlated with the growth of private domestic investment.

However, looking at the data by decade, I see different results for different decades. The relationship between the growth rate of aggregate investment and the growth rate of different disaggregated components of aggregate investment is significantly different for the period of 1982-1990 compared to the last two decades. During most of the 80's, Pakistan was under military rule and public and government investment was the main driver of aggregate investment. However, since the beginning of the new millennium, private investment has become the major driving force behind aggregate investment in Pakistan. This is supported by Table 3A, where correlations for the growth rate of investment and the growth rate of output as well as between the growth rate of private investment and the growth rate of output are significantly positive for the last decade.

Another important result from Table 3A is that the growth in foreign direct investment has become important over time, in particular over the last decade, in explaining the growth of aggregate investment as well as the output. The contemporaneous correlation of FDI with output has increased from 0.07 in the 80's to 0.49 in the last decade. This increased significance of foreign investment is further supported by correlation of 0.82 between aggregate investment and FDI during the last decade.

After the analysis based on contemporaneous correlations, we also look at dynamic correlations in order to better understand the lead lag relationship between different variables. This exercise should be ideally done at a quarterly or monthly frequency but due to unavailability of relevant macroeconomic series at an appropriate frequency, we consider the relevant dynamic correlations at an annual frequency.

The dynamic correlations of different aggregate and disaggregated macro variables with output are presented in Figure 3 & Figure 4. Figure 3 presents the correlations for both growth rate as well as detrended series of output with different components of investment. Data is annual from 1982 to 2010, and the Figure plots the correlation between real GDP, $Y_t$ and $I_{t+j}$ against j, where I represents a disaggregated component of aggregate investment. In order to establish the changing nature of the economy, each panel also has the relevant dynamic correlation by the decade as well.

In Figure 3, the first panel is showing the dynamic correlation for the growth rate of real GDP with real investment. The growth rate of aggregate real investment is significantly positively correlated with the growth rate of output at the first lead for the covered period of 1982-2010. However, it is interesting to note that the dynamic correlations differ considerably between the last two decades and the 80's. This is generally true for the dynamic correlation behaviour of most disaggregated components of aggregate investment with output. During the last decade, the growth rate of aggregate investment is positively correlated with growth rate of output for the first lag as well as for both leads. Therefore, the relationship between aggregate investment and output has been changing over the last decade and the importance of investment for the economy has been highlighted once more.

The behaviour of the growth rate of private investment as measured in terms of its dynamic correlation with the growth rate of output is almost identical to the behaviour of aggregate investment as shown in Figure 3. Only for the last decade, the growth rate of private investment is positively correlated with the growth rate of output at first lag and both leads. On the other hand, for 90's growth rate of private investment is clearly lagging output growth.

The growth rate of all public investment is positively correlated with output

growth for the first and the last decade at the first lead, as well as for the whole period of 30 years. Therefore, growth in all public investment usually lagged behind the growth in output during our period of interest. However, for the 1982-1990 period growth in all public investment was both a leading and lagging indicator of growth in output.

The growth rate of public investment is positively correlated with output growth for all the decades at the first lead as well as for the whole period of 30 years. Therefore, growth in all public investment usually lagged behind the growth in output during our period of interest.

Turning to government investment, we can see that the growth rate of government investment is positively correlated with the growth rate of output for all three decades for the first lag. However, for the last decade the positive correlation with output is stronger for the first lead as well. Therefore, growth in government investment was a leading indicator for the growth of output for the period of 1982-1990. For the period of 2001-2010 growth in government investment was both a leading and lagging indicator for growth in output. For the majority of both decades, Pakistan was under military rule and once again I find evidence supporting the active role of government investment during military regimes.

After looking at the behaviour of growth rates of private and public sector investment, we decided to take a closer look at the role of domestic and foreign contribution to growth of private investment. The evidence presented earlier points towards increasing importance of foreign investment. Therefore, in order to disentangle the importance of domestic and foreign investment in the economy we also look at the dynamic correlations of growth in private domestic investment and foreign direct investment with growth in output respectively.

The growth rate of private domestic investment is not positively correlated

with growth rate of output for the whole period as well as for the first two decade for first lag and first lead. However, for both decades growth in private domestic investment is positively correlated with growth in output for both second lag and second lead. For the last decade, growth of private domestic investment is positively correlated with output growth at both leads and lags. This points toward increasing importance of private domestic investment for economic growth of Pakistan. However, it is important to note that growth in private domestic investment is more likely to follow growth in output rather than leading to output growth.

Finally, the growth rate of foreign direct investment is positively correlated with the growth rate of output at the first lead for all three decades as well as for the complete period from 1982 to 2010. So, for all three decades growth in output is usually followed by a growth in FDI. However, from 2001 onwards growth in FDI is also positively correlated with output growth at the first lag. This implies that growth in FDI is both a leading and lagging indicator of growth in output for the last decade. Therefore, our emphasis on foreign direct investment in driving Pakistani economy in particular during the last decade is further corroborated by dynamic correlations presented in Figure 3.

**Private Consumption, Government Consumption, Exports & Imports**

Table 3B describes the linkages between the growth rate of remaining disaggregated components of output such as private consumption, government consumptions, exports and imports with the growth rate of output.

Over the period of 1982-2010, the growth rate of private consumption, government consumption, exports and imports are all positively correlated with the growth rate of output. The Table also shows that growth rate of

private consumption is most significantly related with growth rate of output same as the growth rate of aggregate investment. Interestingly, growth of both private and government consumption is positively correlated with the growth rate of imports. However, government consumption is also significantly positively correlated with both aggregate investment and FDI. The growth in exports is not significantly positively correlated with any of the disaggregated components of output for the given period. Finally, as mentioned before, the growth rate of imports is correlated with the growth rate of aggregate investment, private consumption and government consumption.

However, looking at the data by decades we see different results for different decades. The relationship of output and different components of output is significantly different for the period of 1982-1990 compared to the other two decades. For this period none of the components of the output are significantly correlated with output. The growth rate of private consumption has the strongest correlation of 0.46 with growth of output. However, for this period growth of exports is significantly negatively correlated with growth of FDI & private consumption. Finally, the growth rate of imports is positively correlated with private consumption growth for this period.

During the 90's the growth rate of private consumption and exports are both significantly positively correlated with output growth. The growth rate of private consumption has a contemporaneous correlation of 0.67 with growth of output and growth of exports has a correlation of 0.68 with output growth. Government consumption is positively correlated with output as well as all other components of output other than the aggregate investment. However, the correlation of growth in government consumption is strongest with the growth rate of FDI. Both exports and imports are positively correlated with output as well as some components of output such as private consumption

and government consumption. Imports, in particular, have strong positive correlation with aggregate investment as well as statistically significant positive correlation with both private and government consumption.

The last decade is the most interesting one in the sense that output is not only positively correlated with aggregate investment as mentioned before but also with all the disaggregated components of output. *This positive correlation of output with different components of output imply that the growth experience of Pakistan in the last decade was not driven only by investment or trade, but the combination of all different components of output. The most interesting finding for this period is the significant positive correlation of imports with investment, FDI and government consumption. This finding combined with the importance of FDI in driving investment and output as discussed previously once again points towards the importance of external shocks for the Pakistani economy.*

The dynamic correlations of growth rate of different components of output with growth rate of output are presented in Figure 4.

Figure 4 presents the dynamic correlations for both growth rate as well as detrended series of output with different components of output. Data is annual from 1982 to 2010, and the Figure plots the correlation between real GDP, $Y_t$ and $PC_{t+j}$, $GC_{t+j}$, $EXP_{t+j}$, $IMP_{t+j}$ against j, where PC, GC, EXP and IMP are private consumption, government consumption, exports and imports respectively.

In order to establish the changing nature of the economy, each panel also has the relevant dynamic correlation by the decade as well.

In Figure 4, the first panel is showing the dynamic correlation for growth rate of real GDP with growth rate of private consumption. The growth rate of private consumption has almost no or negative correlation with the growth

rate of output for the period from 1982-2010. However, it is interesting to note that the dynamic correlations differ considerably between the last two decades and the decade from 1982-1990. This is generally true for the dynamic correlation behaviour of all components of output with output. During the last two decades, the growth rate of private consumption is positively correlated with the growth rate of output for the first lead. Therefore, the relationship between private consumption and output has been changing over the last two decades compared to the 80's.

The growth rate of government consumption is positively correlated with the growth rate of output for the first lead. For all periods, the growth rate of government consumption and growth rate of output is negatively correlated for both lags. Therefore, we can say that growth in output was generally followed by growth in government consumption.

Now turning to trade variables, we first look at the behaviour of exports. For the period of 1982-2010, growth in exports appears to be a leading indicator of output growth. Looking closely at the link between exports and output by decade paints a complicated picture. During the 80's, the growth rate of exports is negatively correlated with the growth rate of output at the first lag and positively correlated at the first lead. This implies that growth in exports followed growth in output during the period from 1982-1990. On the other hand, for the last two decades we find the exact opposite of what happened during the 80's. During last two decades, growth in exports was positively correlated with growth in output at the first lag and negatively correlated for both leads. This implies that growth in exports was followed by growth in output for the last two decades. In other words, an increase in growth of exports led to growth in output during this period. It is important to also point out that this leading behaviour of growth in exports is much more pronounced

for the last decade. *This further lends supports to the importance of external shocks for recent performance of Pakistani economy.*

Finally, the growth in imports has mainly been a result of growth in output. For the period of 1982-2010, growth in imports has been positively correlated with growth in output at first lead and negatively correlated at first lag. The same behaviour is observed for the 90's. However, during the last decade growth in imports is positively correlated with growth in output for both the first lead and first lag. However, the correlation between output growth and imports growth is much stronger for the first lead compared to the first lag. Therefore, growth in imports usually lagged output growth for the period of our analysis.

**HP Filtered Data**

**Aggregate Investment & Other Disaggregated Components of Aggregate Investment**

For the de-trended data, I first look at the investment related variables, as investment and private consumption are both significantly correlated with output according to Table 3B & Table 4B for both growth rate and HP filtered series.

In order to de-trend different macroeconomic series, we use HP filter with $\lambda = 100$, which is the value normally used in the literature for annual data.

The Table 4A describes the linkages between de-trended private investment, de-trended all public investment, de-trended public investment, de-trended government investment, de-trended private domestic investment, de-trended foreign direct investment and de-trended output.

Over the period of 1981-2010, aggregate investment, private investment, all public investment , public investment, government investment and foreign

direct investment are all significantly positively correlated with output.

The Table 4A also shows that aggregate investment is significantly positively correlated with all the disaggregate components of aggregate investment. However, it is most strongly positively correlated with private investment. Interestingly, private investment is strongly positively correlated with private domestic investment, government investment and FDI.

However, looking at the data by decades we see different results for different decades. The relationship of investment with its disaggregated components is different for the three periods of 1981-1990, 1991-2000 & 2001-2010. This once again points towards the continuously evolving nature of economic fluctuations in Pakistan over the last few decades.

However, since the early 1990's private investment has become the major driving force behind aggregate investment in Pakistan. This is further supported by Table 4A, where correlations are significantly positive for each of the last two decades for de-trended aggregate investment and de-trended output as well as between de-trended private investment and de-trended output for the last decade.

Looking at the period of 1981-1990, we find some strange observations, such as strong negative correlation between private investment and output as well as between private domestic investment and output. During this period, aggregate investment was significantly positively correlated with both all public investment and public investment. Also, de-trended government investment was strongly negatively correlated with both private and private domestic investment. This behaviour of aggregate investment and its different components is in line with our earlier explanations regarding military rule and nationalization of investment during this period.

During the last two decades, we find more typical behaviour of aggregate

investment and its disaggregated components. For both decades, de-trended output is positively correlated with aggregate investment as well as with all public investment, public investment, government investment and foreign direct investment.

In addition, for the last decade de-trended output is significantly positively correlated with aggregate investment, private investment, private domestic investment and foreign direct investment. The significant relationship between private investment and aggregate investment is also supported by the correlations reported in Table 4A for the last decade. Finally, the strong link between private investment and aggregate investment as well as output is due to both the domestic[3] component of private investment as well as the foreign[4] one.

Another important result from Table 4A is that foreign direct investment has steadily gained importance over time in explaining short-run fluctuations of aggregate investment as well as the output in particular over the last two decades. The contemporaneous correlation of FDI with output has increased significantly from 0.07 in the 80's to 0.73 for the last two decades. This increased significance of foreign investment is further supported by the correlation coefficient of 0.92 between aggregate investment and FDI during the last decade.

After the analysis based on contemporaneous correlations, we turn our attention to dynamic correlations in order to better understand the lead lag relationship between different de-trended variables of interest. This exercise should be ideally done at a quarterly or monthly frequency, but due to unavailability of relevant macroeconomic series at appropriate frequency, we look at dynamic correlations at an annual frequency.

The dynamic correlations of different de-trended aggregate and disaggre-

[3]private domestic investment
[4]foreign direct investment

gated macro variables with de-trended output are presented in Figure 3 & Figure 4. Figure 3 presents the dynamic correlations for both growth rate as well as HP filtered series of output with growth rate and HP filtered series of different disaggregated components of investment. The data is annual from 1981 to 2010, and the Figure plots the correlation between either the growth rate of real GDP or the de-trended real GDP, $Y_t$ and $I_{t+j}$ against j, where I represents either growth rate of different disaggregated component of aggregate investment or de-trended disaggregated component of aggregate investment. In order to further evaluate the changing nature of the economy, each panel also has the relevant dynamic correlations by the decade as well.

In Figure 3, the second panel is showing the dynamic correlation for HP filtered real GDP with HP filtered real aggregate investment. The de-trended aggregate investment is positively correlated with de-trended output for both lags and both leads for the covered period of 1981-2010. However, it is interesting to note that the dynamic correlations differ from one decade to another. During the last decade, de-trended aggregate investment is positively correlated with de-trended output for the first lag as well as for both leads.

The behaviour of de-trended private investment as measured in terms of its dynamic correlation with de-trended output is similar to the behaviour of de-trended aggregate investment as shown in Figure 3. For the last decade, de-trended private investment is significantly positively correlated with the de-trended output at both first lag and fist lead. For the earlier two decades, it is clear that de-trended private investment was a lagging indicator of de-trended output. However, for the last decade de-trended private investment seems to be both leading and lagging the de-trended output.

The de-trended all public investment is positively correlated with de-trended output for the last two decades at the first lead as well as for the whole period of

30 years. Therefore, de-trended all public investment usually lags de-trended output for the period from 1981-2010. However, only for the 80's, de-trended all public investment is a leading indicator of de-trended output.

On the other hand, de-trended public investment is positively correlated with de-trended output for the whole period of 30 years as well as for all three decades at the first lead. Therefore, de-trended public investment lags de-trended output during the time period covered in our analysis..

In Figure 3, we can see that de-trended government investment is positively correlated with de-trended output at the first lag for the first two decades as well as for the whole period from 1981-2010. Furthermore, for both 80's and 90's de-trended government investment is negatively correlated with de-trended output for both leads. However, during the last decade de-trended government investment is positively correlated with de-trended output for both leads and negatively correlated for both lags. Therefore, de-trended government investment was a leading indicator of de-trended output for the first two decades and a lagging indicator for the last decade.

The evidence presented so far in this section has repeatedly pointed towards the importance of private investment in explaining economic behaviour of Pakistan over the last few decades. Therefore, in order to disentangle the importance of domestic and foreign component of private investment for short-run economic fluctuations we look at the dynamic correlations of de-trended private domestic investment and de-trended foreign direct investment with de-trended output respectively.

The de-trended private domestic investment is positively correlated with de-trended output for the whole period as well as for 80's and the last decade for the first lead. However, it is also positively correlated with output at the first lag for the last decade and at both lags for the whole period of 1981-2010.

This point towards increasing importance of fluctuations in private domestic investment for the fluctuations in output.

Finally, de-trended foreign direct investment is positively correlated with de-trended output at the first lead for the all three decades as well as for the complete period from 1981 to 2010. However, more importantly for the whole period as well as the last decade fluctuations in FDI is strongly positively correlated with fluctuations in output at the first lag as well. This implies that fluctuations in FDI not only follow fluctuations in output but can also lead to fluctuations in the output. Therefore, the role of foreign direct investment in driving Pakistani economy during the last decade as well as for the complete period of our analysis is important for de-trended variables as well.

The short run fluctuations in output are driven by short-run fluctuations in aggregate and private investment. Furthermore, the short run fluctuations in FDI and private domestic investment are strongly correlated with short run fluctuations of output specially for the last decade.

**Private Consumption, Government Consumption, Exports & Imports**

After detailed discussion of contemporaneous correlations and dynamic correlations of de-trended aggregate investment and de-trended output as well as de-trended components of aggregate investment with de-trended output, lets turn our attention to other macroeconomic variables such as private consumption, government consumption, exports and imports.

The Table 4B describes the linkages between different de-trended components of output such as de-trended private consumption, de-trended government consumptions, de-trended exports and de-trended imports with de-trended output.

Over the period of 1981-2010, de-trended private consumption, de-trended government consumption, de-trended exports and de-trended imports are all strongly positively correlated with the de-trended output. The Table also shows that de-trended imports is most strongly positively correlated with de-trended output. Interestingly, both de-trended private consumption and de-trended government consumption are positively correlated with de-trended imports. However, government consumption is also significantly positively correlated with both aggregate investment and FDI. The de-trended exports is only significantly positively correlated with de-trended output. Finally, de-trended imports are positively correlated with all other de-trended components of output except for de-trended exports.

However, looking at the data by decades we see different results for different decades.

The relationship of de-trended output and different de-trended components of output is significantly different for the period of 1981-1990 compared to the other two decades. For this period only, de-trended government consumption is significantly positively correlated with the de-trended output. The de-trended aggregate investment is strongly negatively correlated with de-trended private consumption and positively correlated with de-trended exports. However, for this period de-trended exports is significantly negatively correlated with de-trended private consumption. Finally, de-trended imports is positively correlated with de-trended private consumption for this period.

During the 1990's, all different de-trended components of output are strongly positively correlated with de-trended output. The de-trended private consumption has a contemporaneous correlation of 0.85 with de-trended output. The de-trended private consumption itself is positively correlated with de-trended aggregate investment with a correlation coefficient of 0.56. The de-

trended government consumption is significantly positively correlated with de-trended FDI, de-trended exports and de-trended imports. However, the correlation of de-trended government consumption is strongest with de-trended FDI. Both de-trended exports and de-trended imports are positively correlated with de-trended output as well as all other de-trended components of output.

During the period of 2001-2010, de-trended output is positively correlated with all de-trended components of output and with significant correlations with de-trended aggregate investment, de-trended FDI and de-trended imports. These significant correlations of de-trended output with different de-trended components of output implies that short-run economic fluctuations in the last decade was not driven only by investment or consumption or trade but it was a combination of all.

The most interesting finding for this period is the significant positive correlation of de-trended imports with de-trended aggregate investment, de-trended FDI & de-trended government consumption. These findings combined with the importance of de-trended FDI in driving de-trended output as discussed previously once again emphasizes the importance of external shocks for the short-run economic fluctuations in Pakistan.

The dynamic correlations of different de-trended components of output with de-trended output are presented in Figure 4.

Figure 4 presents the correlations for both the growth rate as well as de-trended series of output with different components of output. The data is annual from 1981 to 2010, and the figure plots the correlation between real GDP, $Y_t$ and $PC_{t+j}$, $GC_{t+j}$, $EXP_{t+j}$, $IMP_{t+j}$ against j, where PC, GC, EXP and IMP are private consumption, government consumption, exports and imports respectively.

In order to establish the changing nature of the economy, each panel also

has the relevant dynamic correlation by decade as well.

In Figure 4, the second panel is showing the dynamic correlation of de-trended output with de-trended private consumption. The de-trended private consumption is positively correlated with de-trended output for the period from 1981-2010 for both leads as well as for the first lag. However, it is interesting to note that dynamic correlations differ considerably decade by decade.

During the 80's, de-trended private consumption is negatively correlated with de-trended output for both lags and the first lead. This implies that for the period of 1981-1990 de-trended private consumption is neither a leading nor a lagging factor for the de-trended output.

For the last decade, de-trended private consumption is positively correlated with de-trended output at both first lag and first lead as well. This means that fluctuations in private consumption are both impacted by fluctuations in output as well as impacting output fluctuations. The positive correlation between de-trended private consumption and de-trended output is stronger for the first lag as compared to the first lead for the last decade.

Therefore, the relationship between private consumption and output has been evolving over time and the increased importance of private consumption for the economy has been highlighted by this simple analysis.

The de-trended government consumption is positively correlated with de-trended output for the first lead for all three decades as well as for the whole period of 1981-2010. In addition, for all three decades de-trended government consumption and de-trended output is negatively correlated for both lags. For the complete period of analysis, there is a positive correlation between de-trended government consumption and de-trended output at the first lag as well. However, the positive correlation is stronger between de-trended govern-

ment consumption and de-trended output for the first lead even for the whole period. Therefore, de-trended government consumption is clearly a lagging indicator for de-trended output for the three decades considered in our analysis. However, it can be both leading and lagging indicator for the period of 1981-2010.

Now turning to trade related variables, we first look at the behaviour of exports. For the period of 1981-2010, there is only slight positive correlation between de-trended exports and de-trended output for the first lead but a strong positive correlation for both lags. Therefore, de-trended exports are clearly a leading indicator of de-trended output for the period of 1981-2010.

However, looking at dynamic correlations of de-trended exports and de-trended output decade by decade paints a different picture. During the 80's & 90's de-trended exports has almost no correlation with de-trended output at first lag and positively correlated at the first lead. This implies that fluctuations in exports followed fluctuations in output during the first two decades.

On the other hand, for the last decade we find the exact opposite of what happened during the first two decades. In the period from 2001-2010, de-trended exports is significantly positively correlated with de-trended output at both lags and negatively correlated for both leads. This implies that fluctuations in exports were followed by fluctuations in output. In other words, an increase in de-trended exports led to an increase in de-trended output during this period. Therefore, de-trended exports was a leading indicator of de-trended output for the last decade. This further lends support to the importance of external factors for economic fluctuations in Pakistan.

Finally, fluctuations in de-trended imports has mainly been a result of fluctuations in de-trended output. For the period of 1981-2010, de-trended imports has been positively correlated with de-trended output for both lags

and both leads. However, the behaviour of de-trended imports and de-trended output is markedly different for all three decades. For the 80's, there seems to be no relationship between the two variables neither at lags nor at leads. In the second decade of interest, de-trended imports are a lagging indicator of de-trended output. Finally, during the last decade de-trended imports was positively correlated with de-trended output at both first lead and first lag. However, the positive correlation between de-trended output and de-trended imports is much stronger for the first lead compared to the first lag. Therefore, even for the last decade we can't claim de-trended imports to be a leading variable for de-trended output. At best, de-trended imports are both a lagging and leading indicator of de-trended output for the last decade.

The empirical results discussed in this section once again highlight the importance of external factors such as fluctuations in exports as a leading cause or indicator of fluctuations in aggregate output for a small open economy like Pakistan. In particular, as pointed out earlier all of these results are found to be much more stronger for the period starting from 1990's and much stronger for the last decade.

### 3.2.4 Not So 'Stylized Facts' of Pakistani Business Cycles

After a detailed discussion of different structural and empirical facts of Pakistani economy over the period of 1981-2010, now I can finally introduce and discuss the so called stylized facts of the Pakistani business cycles for our main period of interest as well as for each of the three decades that we have analysed throughout the empirical section. The business cycles are usually characterized by **volatility, relative volatility, co-movement and persistence** of different macroeconomic variables of a given economy. Before continuing with

my analysis, it is important to mention that for a developing economy like Pakistan 'stylized facts' are not very well known and there is no clear consensus on what are actually the 'stylized facts' of the economy. Data inconsistencies are one of reasons for this lack of consensus as well as the continuously changing nature of economic fluctuations in Pakistan. Therefore, in this section I present my not so 'stylized facts' for the business cycles of Pakistan for both growth rate and de-trended series of the relevant macroeconomic series. Furthermore, I only discuss the 'stylized facts' for the last 30 years and the relevant statistics for each decade are reported in Table 5 in the Appendix A.

### Growth Rate

The relevant second moments for the growth rate of real output, real aggregate investment, real private consumption, real government consumption, real exports, real imports and real FDI are reported in Table 5 of the Appendix A. The business cycles are usually characterized by volatility, relative volatility, co-movement and persistence of different macroeconomic variables of a given economy. Therefore, I look closely at each of these group of moments closely for the Pakistani economy for the period of 1982-2010.

The growth rate of real output is more volatile then most of the developed economies[5]. The magnitude of volatility of the growth rate of real output is very similar for the whole period of 30 years as well as for the last decade. However, rather than discussing the absolute volatility of different macroeconomic variables. It is useful to consider the relative volatility with respect to real output of these variables. As usual, the measure of absolute and relative volatility are standard deviations of the time series of a given variable and the ratio of the standard deviation of a given variable to standard deviation of

[5]Aguiar and Gopinath (2007)

output.

Interestingly, the growth rate of all the relevant macroeconomic variables such as aggregate investment, FDI, private consumption, government consumption, exports and imports are all more volatile than the growth rate of output. The growth rate of real aggregate investment is about 4 times as volatile as the growth rate of real output. Private consumption is least volatile among all other components of output. The growth rate of private consumption is one and half time as volatile as growth rate of output. On the other hand, government consumption is the most volatile variable other than FDI. The growth rate of government consumption is almost 7 times as volatile as output. The trade variables are also more volatile than real output. As the growth rate of exports is more than 4 times as volatile as growth rate of output and the growth rate of imports is more than 5 times as volatile as output. Finally, foreign direct investment is the most volatile variable relative to output. The relative volatility of growth rate of FDI to growth rate of output is 25.

After discussing relative volatility of different macroeconomic variables relative to output for the last 30 years, I consider the same dispersion measures for the last decade. The nature of economic fluctuations in Pakistan has been continuously evolving. Therefore, it is important to be aware of what has happened over time in the economy as well as to focus on the main changes that have taken shape over the last few years. The relative volatility of aggregate investment with respect to output has increased over the last decade. Government consumption is still the most volatile component of output, but now the magnitude is even higher from before. However, relative volatility of private consumption, exports and FDI have declined over the last decade. Finally, relative volatility of imports has been increasing over the last decade.

After volatility, we turn our attention to co-movement between the growth

rate of output and the growth rate of other macroeconomic variables. During the period of 1982-2010, the growth rate of aggregate investment, private consumption, government consumption, exports, imports and FDI all are significantly positively correlated with growth rate of output. This pro-cyclical behaviour of variables is strongest for aggregate investment, private consumption and imports respectively. Finally, for the last decade the correlation of growth rate of output is strongest with growth rate of aggregate investment, growth rate of private consumption and growth rate of FDI. *This is in line with evidence presented thus far for the importance of aggregate investment in general and foreign direct investment in particular for explaining economic fluctuations of Pakistani economy for the last few decades.*

Finally, we consider the persistence of various macro variables of interest over the period from 1982-2010 as well as for each of the three decades. Output and aggregate investment are the only variables that display persistence for the whole period. On the other hand, for the last decade persistence of both growth rate of output and growth rate of aggregate investment has increased as well as growth rate of FDI being persistent as well. This lack of persistence in most of the macro variables is further proof of changing nature of economic fluctuations in Pakistan. However, the autocorrelation coefficients for the last decade point towards increase in persistence level for most of the variables.

**HP Filtered Data**

The second order moments for de-trended output, aggregate investment, private consumption, government consumption, exports, imports and FDI are reported in Table 6 of the Appendix A. The business cycles are usually characterized by volatility, relative volatility, co-movement and persistence of different de-trended macroeconomic variables of a given economy. Therefore, I

investigate these second order moments closely for the Pakistani economy for the period of 1981-2010 in order to get a better understanding of Pakistani business cycles over the last three decades.

The de-trended output for Pakistan over the last 30 years is more volatile then most developed economies[6]. The magnitude of volatility of de-trended real output is very similar for the whole period of 30 years as well as for the last two decades. However, rather than discussing the absolute volatility of different macroeconomic variables for all the periods, we will focus our attention on relative volatility with respect to real output of these variables. The relative volatility is measured as a ratio of the standard deviation of a given de-trended macroeconomic variable to the standard deviation of de-trended output.

For the period of 1981-2010, all the de-trended macroeconomic variables are more volatile than de-trended output. The de-trended aggregate investment is about four and half times as volatile as de-trended real output. Private consumption is clearly the least volatile among all other components of output. Private consumption is less than one and half time as volatile as output. On the other hand, government consumption is the second most volatile variable after FDI. The de-trended government consumption and de-trended imports are around 5 times as volatile as de-trended output. The de-trended exports is around three and a half times as volatile as output. Finally, foreign direct investment is the most volatile variable relative to output. The relative volatility of FDI to output is 17.6.

The nature of short term economic fluctuations in Pakistan has been continuously evolving. Therefore, one should be aware of what has happened over time in the economy as well as focus on the main features of the last few years

[6]Aguiar and Gopinath (2007)

to come up with an appropriate business cycles model. During the period 2001-2010, relative volatility of aggregate investment, government consumption, imports and FDI is higher from the magnitudes of relative volatilities of these variables for the whole period. On the other hand, relative volatility of private consumption and exports with respect to output has been consistently declining over time and reaching their lowest values in the last decade. This decline in relative volatility indicates possible similarities between Pakistani business cycles as well as business cycles of developed economies in recent times. In particular, the decline in relative volatility of private consumption with respect to output can be a sign that the Pakistani economy is moving towards behaving like a developed economy as far as the second order moments are concerned.

The co-movement of de-trended output with de-trended macro variables helps us in classifying them as pro-cyclical, a-cyclical or counter-cyclical variables with respect to output. During 1981-2010, de-trended aggregate investment, private consumption, government consumption, exports, imports and FDI all are significantly positively correlated with de-trended output. This strong pro-cyclical behaviour is strongest for imports, aggregate investment, and FDI. The de-trended private consumption, government consumption and exports are also but to a lesser degree significantly positively correlated with output.

This trend still holds for the last decade. All the de-trended variables including private consumption, government consumption and exports are positively correlated with de-trended output. However, de-trended aggregate investment is clearly most significantly positively correlated with de-trended output. The de-trended imports and de-trended FDI are the other two significantly pro-cyclical variables. The behaviour of different de-trended macro

variables over the last three decades in general and for the last few years in particular consistently highlight the importance of aggregate investment and imports in explaining fluctuations in output for Pakistani economy over the last few decades and possibly in the future.

Finally, we consider the persistence of relevant de-trended macro variables for the period 1981-2010 as well as by decade. All the de-trended variables exhibit some persistence. However, output, aggregate investment, FDI and imports are the most persistent out of all the variables. The persistence level has stayed the same for output and aggregate investment and has been increasing for some of the other de-trended variables. In particular, the autocorrelation of exports and FDI has both increased for the last decade.

### 3.2.5 Summary of Stylized Facts by Category

In order to focus on the main empirical findings for Pakistan over the last few decades. Lets recall the main points of this section:

**Structural facts and long-run ratios (1960-2010)**

- Pakistan has always been an agrarian economy, from its independence till now even after more than 60 years.
- The nature of production has shifted away from agriculture to mainly services and industry.
- However, employment shares still indicate that the agriculture sector still maintains a lion share of the real economy
- The long run ratios of the economy such as investment to output, private consumption to output, government consumption to output, exports to

output and imports to output all display volatility over time instead of having a stable trend.

- The volatility of the investment to output ratio has become more pronounced over the last two decades.

- Looking further into disaggregated components of investment, I find that share of private investment in aggregate investment has taken over the share of public investment over the last couple of decades.

- This decline in share of public investment, in particular over the last decade, has been accompanied by an increase in foreign direct investment to the economy.

- The long run ratio of private consumption to output is volatile and displays cyclical behaviour. Private consumption has always been the largest component of output in Pakistan. However, it is important to keep in mind that private consumption data in Pakistan is computed as a residual.

- The government consumption to output ratio is also very volatile and seems to follow a cyclical pattern. It has been particularly more volatile over the last decade.

- Both trade related long run ratios, namely exports to output and imports to output show a significant jump in the early 70's.

- The magnitude of both the exports to output and imports to output ratio increased significantly in early 70's.

- Trade has accounted for more than one third of output over the last three decades. This lends credence to treating Pakistan as a small open

economy.

- The long run behaviour of the economy has changed over time. The behaviour of long run ratios for the first two decades and the last three decades differ by volatility as well as for magnitude for some variables.

**Correlations and Dynamic Correlations (1981-2010)**

- For the last three decades, the growth rate of output is most significantly positively correlated with growth rate of aggregate investment, growth rate of private consumption and growth rate of imports.

- The growth rate of output also has positive contemporaneous correlation with growth rate of government consumption and growth rate of exports.

- The relationship between growth rate of output and growth rate of other macroeconomic variables is similar even when compared decade by decade. However, there are some differences between the three decades. In particular, 80's results are different from the correlations for the last two decade.

- The growth of most of the macroeconomic variables are lagging behind the growth in output. Therefore, dynamic correlation analysis points out that only growth rate of exports for the last decade was a clear leading indicator of growth in output.

- The growth in government investment was a leading indicator of growth in output during the period from 1982-1990. Furthermore, for the last decade growth of government investment was both a leading and a lagging indicator of output growth.

- FDI growth was usually followed by output growth for most of the period of interest. However, for the last decade in our analysis FDI growth was both a leading and lagging indicator of output growth.

- For the period from 1981-2010, de-trended output is significantly positively correlated with de-trended imports, de-trended aggregate investment, de-trended government consumption, de-trended private consumption, de-trended exports and de-trended FDI.

- The contemporaneous correlation of de-trended output is strongest with de-trended imports, de-trended aggregate investment and de-trended FDI.

- The co-movement between de-trended output and other de-trended macro variables differ significantly by decade.

- During the 80's only de-trended government consumption is significantly positively correlated with de-trended output. Furthermore, all other de-trended variables have almost no correlation with de-trended output during the first decade in our analysis.

- On the other hand, there is a positive correlation between de-trended output and all de-trended macroeconomic variables for the 90's. The positive correlation is statistically significant for de-trended private consumption, de-trended exports, de-trended FDI, de-trended imports and de-trended government consumption.

- During 90's, de-trended private consumption and de-trended exports are the most strongly correlation macro variables with de-trended output.

- For the last decade, once again there is a positive correlation between de-trended output and all de-trended macro variables of interest.

- However, the positive correlation is significant only for aggregate investment, imports and FDI.

- Most of the de-trended macroeconomic variables are lagging behind de-trended output, or for most of them, are both lagging and leading de-trended output. Therefore, dynamic correlation analysis points out that de-trended exports is the only clear leading indicator of de-trended output.

- The leading relationship of de-trended exports with de-trended output is strongest for the last decade.

- The stylized facts of business cycles in Pakistan for the given period for the growth rate are:

**The 'stylized facts' of Business Cycles (1981-2010)**

**Growth Rates**

- The growth rate of all macroeconomic variables are more volatile than the growth rate of output for given period of interest.

- The growth rate of aggregate investment is four times as volatile as the growth rate of output. The private consumption growth rate is one and half times as volatile as the growth rate of output, growth rate of government consumption and FDI are seven and twenty-five times more volatile than output. Finally, exports and imports growth are more than four and more than five times as volatile as growth of output respectively.

- The growth rate of aggregate investment, private consumption, government consumption, exports, imports and FDI are all positively correlated with growth rate of output.

- This pro-cyclical behaviour is strongest for growth rate of aggregate investment, private consumption and imports.

- The growth rate of output is most strongly correlated with growth of aggregate investment, growth rate of private consumption and growth rate of FDI for the last decade.

- The growth rate of output and growth rate of aggregate investment are the only variables that show any kind of persistence.

**HP Filtered Data**

- All de-trended macroeconomic variables are more volatile than de-trended output for the period 1981-2010.

- The de-trended aggregate investment is four and a half times as volatile as de-trended output. The de-trended private consumption is the least volatile variable, with it being less than one and half times as volatile as de-trended output.

- The de-trended government consumption and de-trended imports are around five times as volatile as de-trended output. De-trended exports are about three and half times as volatile as output. Lastly, de-trended FDI is the most volatile variable.

- During the last decade, relative volatility of aggregate investment, government consumption, imports and FDI is higher from the values for the whole period.

- The de-trended aggregate investment, private consumption, government consumption, exports, imports and FDI are all significantly positively correlated with de-trended output.

- This pro-cyclicality of variables is strongest for de-trended imports, aggregate investment and FDI.

- The de-trended output is significantly positively correlated with de-trended aggregate investment, de-trended imports and de-trended FDI for the last decade.

- The de-trended macroeconomic variables that show persistence during the period of 1981-2010 are output, aggregate investment and FDI. For the last decade, de-trended exports and de-trended imports also show persistence in addition to de-trended output, aggregate investment and FDI.

## 3.3 Model

After discussing in detail different structural and so-called stylized facts of the Pakistani economy over the last few decades, I finally turn my attention to an appropriate economic model that can help us explain the aggregate fluctuations of the economy. Our empirical evidence has repeatedly pointed towards the importance of aggregate investment, FDI and imports in explaining short-run fluctuations in output over the last 30 years and in particular for the last decade. However, in this paper I start from the simplest of RBC model first and then introduce and augmented version of the simple real business cycles model. The idea is to see how far these simple models can take us in explaining recent aggregate fluctuations of Pakistani economy.

### 3.3.1 A Simple Real Business Cycles Model

In order to evaluate the ability of a simple real business cycles model to capture cyclical fluctuations of Pakistani economy, I consider the most basic RBC model which is easily available in most macro books. Our model is a closed economy representative agent model with exogenous technology shock. The representative agent in our simple RBC model tries to maximize the following separable utility function over an infinite time horizon

$$max\ E_t \sum_{i=0}^{\infty} \beta^t \left[ \ln C_t + \psi \frac{(1 - N_t)^{1-\sigma}}{1 - \sigma} \right] \tag{3.1}$$

where $E_t$ is the expectation at time $t$, $\beta$ is the discount rate, $C_t$ is the consumption of our representative agent at time $t$, $N_t$ represents the number of hours spent working, $\frac{-1}{\sigma}$ is the frisch elasticity of leisure and $\psi$ is the parameter explaining the utility gained by our representative agent through leisure. This utility function is consistent with balance growth.

The representative agent tries to maximize the infinite stream of utilities given that in each period he/she faces the following budget constraint. The equation below is actually the typical aggregate resource constraint for a closed economy without government.

$$C_t + I_t = Y_t \tag{3.2}$$

where $I_t$ is the aggregate investment in the economy at time $t$ and $Y_t$ is aggregate output.

The production in this economy follows a simple cobb-douglas function. The output in the economy depends on physical capital, labor and technology

according to the following equation.

$$Y_t = K_t^{1-\alpha} (A_t N_t)^{\alpha} \tag{3.3}$$

$Y_t$ is the output, $K_t$ represents physical capital, $A_t$ denotes technology and $N_t$ is labor. $(1-\alpha)$ is the share of capital in production.

The physical capital in this economy gets accumulated according to following capital accumulation equation:

$$K_{t+1} = (1-\delta)K_t + I_t \tag{3.4}$$

where $\delta$ is the depreciation rate of capital.

Finally, we model technology by using total factor productivity as a proxy for technological progress. Technology is exogenous as is typical in RBC literature and it follows an AR-1 process.

$$ln\,(A_{t+1}) = \rho_A ln\,(A_t) + \epsilon_{A,t} \tag{3.5}$$

### 3.3.2 Augmented Real Business Cycles Model

The augmented RBC model is similar to the typical closed economy RBC model presented earlier. Indeed, the augmented model also has a representative agent that tries to maximize the infinite stream of discounted utilities given the budget constraint. The main innovation is the introduction of an exogenous FDI shock and the division of aggregate investment into domestic and foreign components in our capital stock accumulation Eq.(6).

This model is isomorphic to a RBC model with investment-specific technology shock as studied by Greenwood, Hercowitz and Huffman (1988) and Greenwood, Hercowitz and Krusell (1997). The main difference between their

model and ours is that they use the relative price of investment as the exogenous shock to aggregate investment and we use FDI. However, the propagation mechanism in both models work in a very similar manner

To be precise, there are now two types of investment in our closed economy. $I_t$ denotes domestic investment which is our typical aggregate investment that is usually incorporated in these closed economy RBC models. On the other hand, $I_t^*$ is the foreign investment which we are interpreting as foreign direct investment:

$$K_{t+1} = (1 - \delta)K_t + I_t(I_t^*)^{\gamma_t} \tag{3.6}$$

The reason we introduce FDI in our augmented RBC model is the abundant empirical evidence presented in the previous section supporting the significant role of FDI and trade variables in driving the business cycle fluctuations of the Pakistani economy over the last few decades and in particular for the last decade.

Our specification in above equation implies that there is strong complementarity between foreign and domestic investments in Pakistan. This is an important point as I also tried more general alternative specifications, such as CES, which produced an empirical fit inferior to the above model. Therefore, the assumption of complementarity between the two types of investment is needed to get the model to capture key facts from the data.

However, another possibility is that both domestic and foreign investment respond to an underlying common shock process, such a investment-specific technology shock, changes in tax or regulatory structure, business confidence, stability, political change etc., that drives all investment decisions.

Another important point is that I should have considered a small open economy model in order to properly model the FDI channel as well as the external sector. However, the purpose of this paper is to mainly establish some

structural and stylized facts of Pakistani economy and evaluate the performance of simplest of closed economy RBC models in replicating the relevant moments of Pakistani economy. The idea is to see how far can one get in terms of matching the stylized facts of the economy even with these simple models.

Therefore, the foreign component of investment is modelled simply as an exogenous shock very much like how a typical exogenous technology shock is incorporated in these models.

$$ln\left(I^*_{t+1}\right) = \rho_{I^*} ln\left(I^*_t\right) + \epsilon_{I^*,t} \tag{3.7}$$

where $\rho_{I^*}$ is the persistence of the exogenous fdi shock and $\epsilon_{I^*,t}$ is the standard error associated with the shock.

Finally, technology shock is the same as before,

$$ln\left(A_{t+1}\right) = \rho_A ln\left(A_t\right) + \epsilon_{A,t} \tag{3.8}$$

where $\rho_A$ and $\epsilon_{A,t}$ are the persistence and standard error of the technology shock respectively.

## 3.4 Calibration & Results

In this section, I first discuss the calibration of different parameters of the model. It is important to have a good understanding of rationale behind picking different parameter values in order to properly evaluate the fit of the model. After calibration, I compare second order moments obtained from simulations of our two models and their empirical counterpart. Finally, I take a brief look at the impulse response functions from both the simple and augmented RBC model for both exogenous shocks to technology and FDI.

### 3.4.1 Calibration

Due to data limitations all parameters in our model are calibrated for annual frequency. There are 10 parameters in total with 6 structural and 4 shock related parameters. Structural parameters can be categorized into utility and production function related parameters. We have generally adopted two approaches in terms of calibrating parameters for our models. Some of the parameters, for which estimation remained an issue due to lack of reliable and detailed data, are picked from existing RBC/DSGE literature for developing and developed countries. Some of the parameters with available data, have been calibrated using partial estimation/computation approach.

First of all, we discuss parameters related to household utility. The value of discount factor $\beta$ used in the existing literature ranges from 0.925 to 0.99 for annual frequency for developing countries. We decided to use a value of 0.95 as it falls in the middle of that range as well as being the widely accepted value for RBC/DSGE models of annual frequency for developed countries like the US. Furthermore, this calibrated value of $\beta$ is also consistent with long run behavior of Pakistani economy.

$\Psi$ reflects household's preference for leisure and a value of 2.80 for this parameter is taken from DiCecio and Nelson (2007). Coefficient of labour supply in utility function $\phi$ is fixed at 1.5 following Fagan and Messina (2009). This value is consistent with the posterior mean reported by Smets and Wouter (2007).

$\alpha$ and $\delta$ are the main parameters related to production. To calibrate the share of capital in production $\alpha$, we took a value of 0.50 which is quite close to the average of capital shares of other developing countries as reported by Liu (2008). Depreciation rate $\delta$ has been set at 0.10 which is within the range of values used in the literature for annual DSGE models for developed and

developing countries such as $\delta = 0.1255$ as used by Garcia, et al. (2010). In addition, balance sheet analysis of joint stock companies listed at the Karachi Stock exchange reveals that the overall depreciation rate has been close to 10 percent. Therefore, in order to be consistent with both the existing literature and empirical evidence from Pakistani firms we use the value of 0.10.

The two exogenous shock processes for technology and FDI are estimated using the method of King and Rebelo (2000). Following our estimation we set persistence $\rho_A$ and standard deviation of technology shock $\sigma_A$ to 0.90 and 0.02 respectively. Similarly $\rho_{I^*}$ and $\sigma_{I^*}$ are fixed at 0.59 and 0.34 respectively. The data for these estimations of shock related parameters has been acquired from Federal Bureau of Statistics (FBS) and State Bank of Pakistan (SBP). The details of estimation of shock parameters are discussed in the Appendix C at the end of the paper.

### 3.4.2 Results

In order to evaluate the performance of the two models discussed in this paper. I will compare steady-state ratios from the models with their empirical counterpart. Furthermore, the relevant second order moments such as standard deviation, contemporaneous correlation with output and autocorrelation of different variables will also be evaluated from the models and their fit with the empirical evidence presented earlier.

In the closed economy models, the two relevant long-run ratios are private consumption to output ratio and aggregate investment to output ratio. Furthermore, output in this case is defined as the combination of private consumption and aggregate investment. The Table 7 in the Appendix A shows that our model respectively give values of 0.67 and 0.33 for private consumption to output and aggregate investment to output ratio. The values obtained

from our models are similar to the values obtained from the data. However, our models overshoots the value of investment to output ratio and undershoots the private consumption to output ratio.

The Table 7 also shows different second order moments from the two models as well as their empirical counterpart for the period from 1981-2010 and the last decade respectively. We had earlier reported the second order moments for output, aggregate investment, private consumption, government consumption, exports, imports and FDI from annual data. However, since our models are closed economy models we will only compare the second order moments for output, private consumption, aggregate investment and FDI from our models and their empirical counterparts.

The basic RBC model with only technology shock underestimates the absolute and relative volatility of both private consumption and aggregate investment. In particular, the relative volatility of aggregate investment and private consumption are 2.28 and 0.45 respectively according to the RBC model. However, according to Pakistani annual economic data these should be around in the range of 4.50 to 6.32 for aggregate investment and between 0.89 and 1.31 for private consumption.

On the other hand, the augmented RBC model does relatively better for both private consumption and aggregate investment in terms of their relative volatility. The relative volatility of private consumption with respect to output is 1.04 and relative volatility of aggregate investment is 2.80. The augmented model still underestimates the relative volatility of aggregate investment but it is higher than the simple RBC model. The improvement in relative volatility is significant for private consumption as it more than doubles from the simple model version and also lies within the reported empirical range.

In terms of contemporaneous correlation of macro variables with output,

simple RBC model overshoots the correlation for both aggregate investment as well as private consumption. The Table 7 in Appendix A shows that augmented model does a better job of matching the correlations of both aggregate investment with output and private consumption with output. In particular, correlation of aggregate investment and output for the period 1981-2010 was 0.72 from the data. According to the RBC model this correlation was 0.98 and 0.74 according to the augmented model. Therefore, augmented RBC model outperforms the basic RBC model in terms of matching correlation moments as well.

Finally, in terms of autocorrelation moments both models perform equally well. Both models do a good job of matching the autocorrelation coefficient of output. However, both models underestimate the autocorrelation of aggregate investment and overestimate the persistence of private consumption. This can be due to the continually changing dynamics of private consumption and aggregate investment and possibly due to the residual nature of computing private consumption in Pakistan.

Overall, the augmented RBC model with technology and FDI shocks outperforms the simple RBC model with only technology shock in terms of matching the empirical second order moments such as volatility, contemporaneous correlation and autocorrelation.

### 3.4.3 Impulse Response Functions

After considering the steady state ratios and second order moments for both models and their empirical counterparts, next we analyze the impulse response functions generated in response to the respective exogenous shocks for the two models. The simple RBC model has the typical exogenous technology shock. On the other hand, augmented RBC model also has an exogenous FDI shock

in addition to the exogenous technology shock.

Figure 7 shows that, in a simple RBC model a positive technology shock leads to a rise in investment, output and consumption. As a result of a positive technology shock investment rises the most followed by output and consumption. These impulse responses are in line with impulse response functions of a typical RBC model.

The Figure 8 shows the impulse response functions in response to both technology and FDI shocks for the augmented RBC model. The impulse response functions for investment, consumption and output in response to a technology shock for the augmented model are almost identical to the IRFs from the simple RBC model.

Interestingly, in response to a positive FDI shock in the augmented RBC model investment, consumption and output all rise immediately. The magnitude of the rise is largest for investment as expected as FDI shock operates directly on investment. After a few periods, investment falls below the steady state level before reverting back to original pre-shock levels. The impulse response of aggregate investment tapers off after few periods, in line with the smaller persistence of the exogenous FDI shock. The behaviour of impulse response functions for consumption and output is very similar to their response to an exogenous technology shock. The only difference is their magnitude and persistence is adjusted according to the parameters of the FDI shock. Also, the FDI shocks gets propagated to output indirectly through aggregate investment. This is different from the case of technology shock as technology directly impacts the output. The IRF of consumption displays a hump shape as is already well documented in the literature.

## 3.5 Conclusion

In this paper, I establish some basic empirical facts of 'documented' Pakistani economy over the last few decades. In addition, I also conduct detailed analysis using contemporaneous and dynamic correlations to identify the relevant macroeconomic linkages that can explain short term fluctuations in output. This paper also discovers some stylized facts regarding business cycle fluctuations of Pakistani economy in particular over the last few decades.

Furthermore, I evaluate the performance of a typical RBC and an augmented RBC model with an exogenous FDI shock in explaining cyclical fluctuations experienced by the Pakistani economy. I find that augmented RBC model performs better compared to the simple RBC model in terms of matching long-run ratios as well as second order moments of Pakistani economy.

To conclude, although I have discussed in detail the evolution of the economy and where it stands now, it strikes me that the only 'stable' stylized fact is the instability that exists in key economic ratios and relationships. This is especially true for the last three decades. What is more of a concern is that this instability has increased over the last decade. This paper is a first step in understanding and modelling the economic fluctuations of a small open economy like Pakistan. However, this paper shows that even a simple model with an exogenous external sector shock can go far in explaining business cycles of the country for the last 30 years and in particular for the last decade.

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## 3.A Chapter 3 Estimation of Shock processes $(\rho_A, \rho_{I^*}, \sigma_A, \sigma_{I^*})$

TFP series is obtained by using residuals of estimated neo-classical production function thorough following regression:

$$\ln Y_t = \alpha \ln K_t + (1-\alpha) \ln L_t + \ln A_t$$

To estimate $\rho_A$, I estimate the following equation:

$$\ln A_t = c + \rho_A \ln A_{t-1} + u_t^A$$

$\sigma_A$ is calculated using residuals of above equation.

Owing to the unavailability of actual data, capital stock series has to be calculated using interpolation methods. There are different ways to calculate capital stock series and parameters of technology shock process are sensitive to variations in capital stock series. Using different series, we get a range of estimates for $\rho_A$ 0.85-0.95 and $\sigma_A$ 0.0095-0.025. From these ranges, we choose values of 0.9 and 0.02 for $\rho_A$ and $\sigma_A$ respectively.

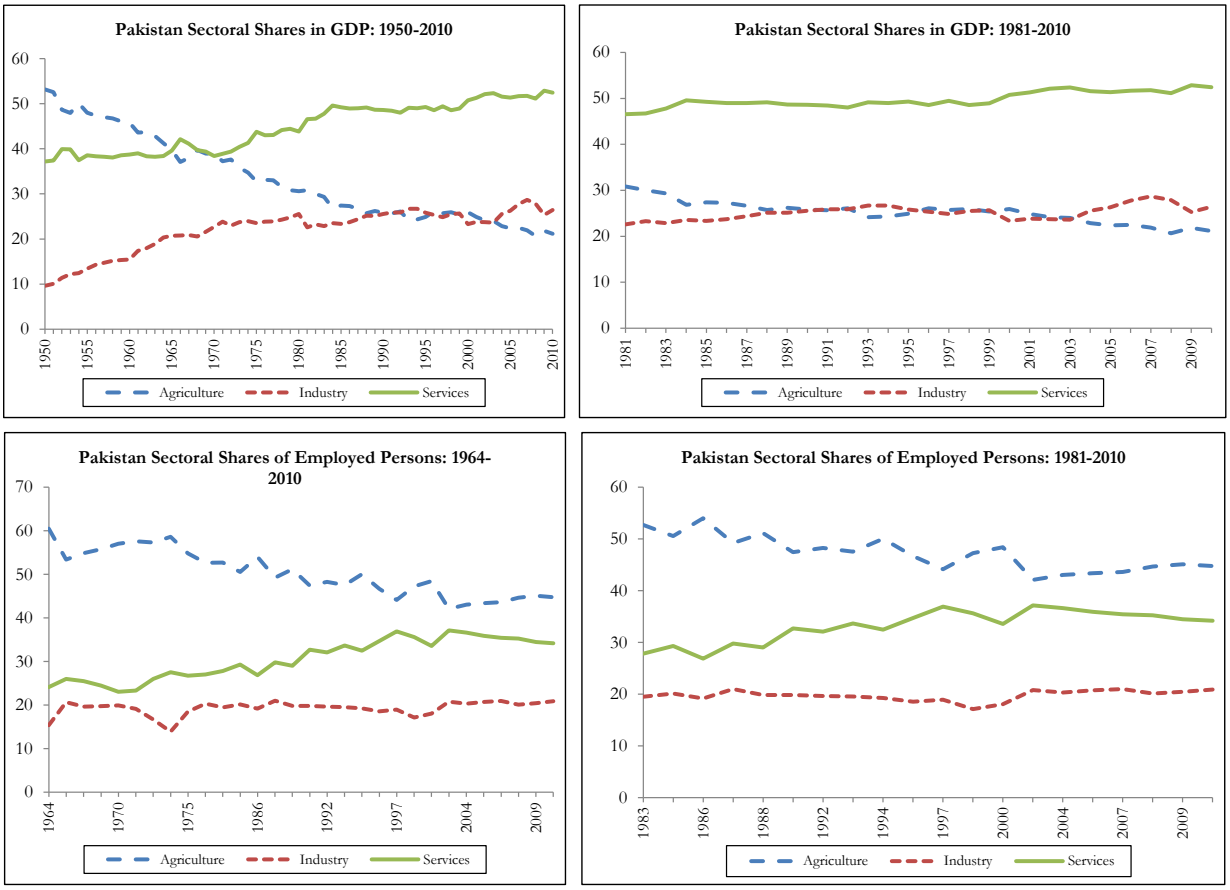
To obtain $\rho_{I^*}$ and $\sigma_{I^*}$, we estimate the following equation:

$$\ln {I^*}_t = c + \rho_{I^*} \ln {I^*}_{t-1} + \mu_t^{I^*}$$

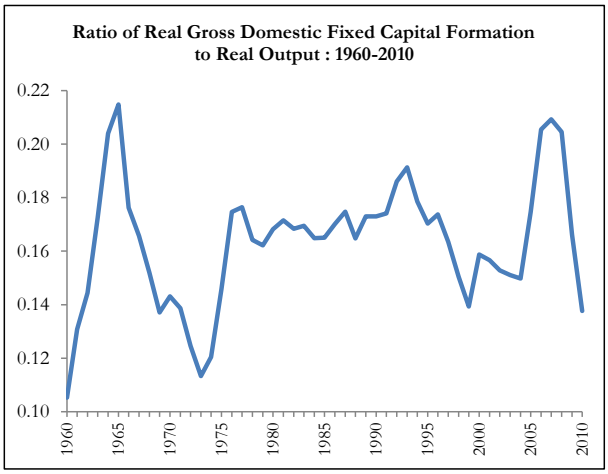
Using log of real per capita FDI, estimation yields values of 0.59 for $\rho_{I^*}$. Standard deviation of residuals from above regression yields estimate of $\sigma_{I^*}$ that is 0.34.

## 3.B Chapter 3 Figures & Tables

## Figure 1


Pakistan Sectoral Shares in GDP: 1950-2010
Agriculture
Industry
Services
Pakistan Sectoral Shares in GDP: 1981-2010
Agriculture
Industry
Services
Pakistan Sectoral Shares of Employed Persons: 1964-2010
Agriculture
Industry
Services
Pakistan Sectoral Shares of Employed Persons: 1981-2010
Agriculture
Industry
Services

## Figure 2A (i)


Ratio of Real Gross Domestic Fixed Capital Formation to Real Output : 1960-2010
0.22
0.20
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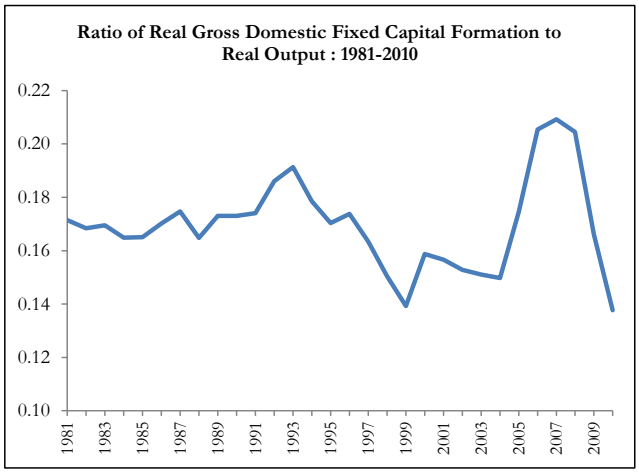
Ratio of Real Gross Domestic Fixed Capital Formation to Real Output : 1981-2010
0.22
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0.16
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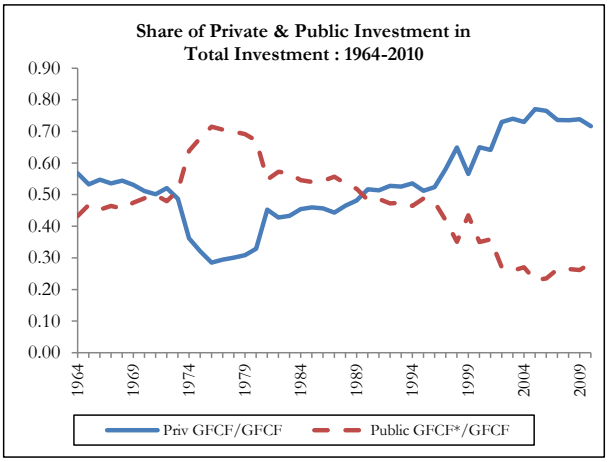
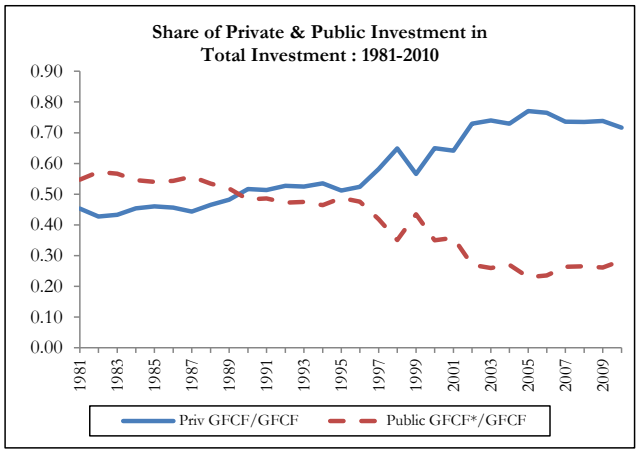
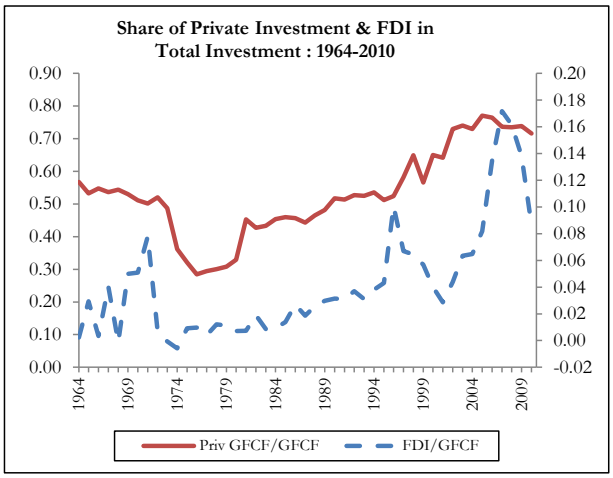
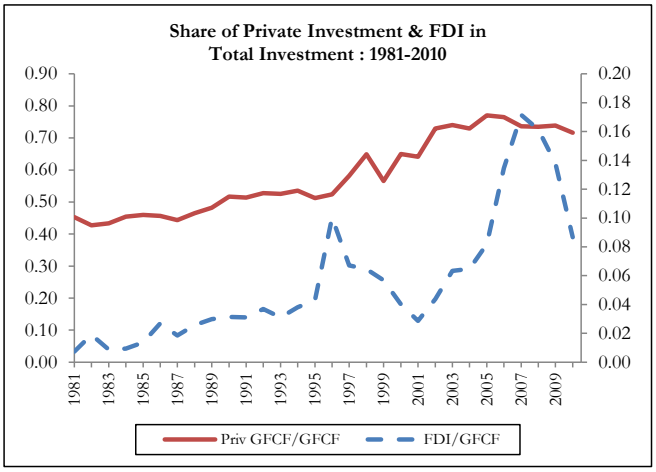
2009

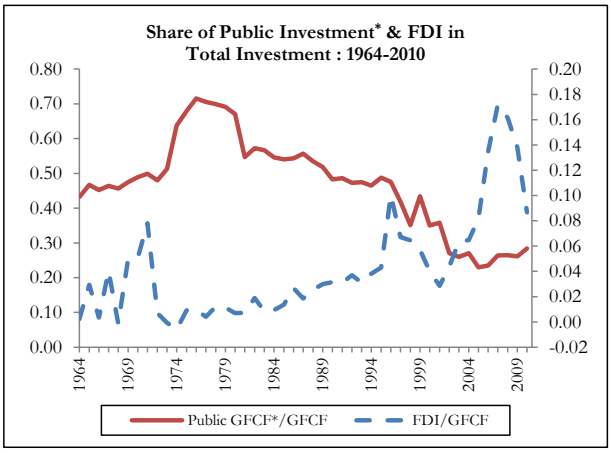

Share of Private & Public Investment in Total Investment : 1964-2010
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1964
1969
1974
1979
1984
1989
1994
1999
2004
2009
Priv GFCF/GFCF
Public GFCF*/GFCF

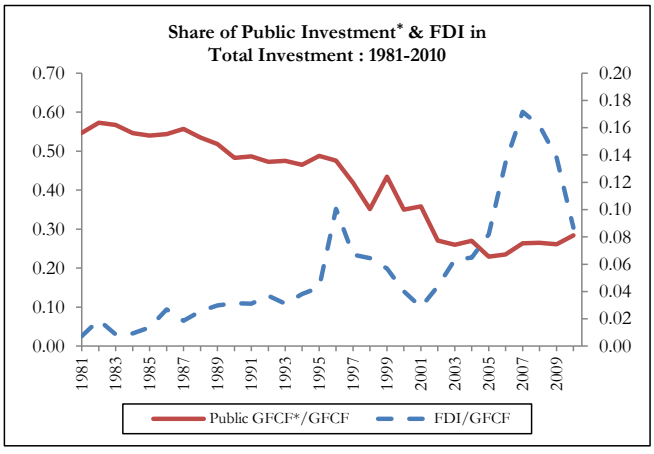

Share of Private & Public Investment in Total Investment : 1981-2010
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Priv GFCF/GFCF
Public GFCF*/GFCF

## Figure 2A (ii)

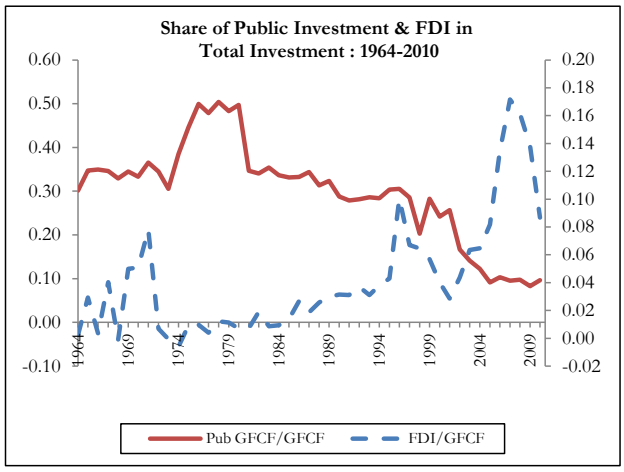

Share of Private Investment & FDI in
Total Investment : 1964-2010
Priv GFCF/GFCF
FDI/GFCF

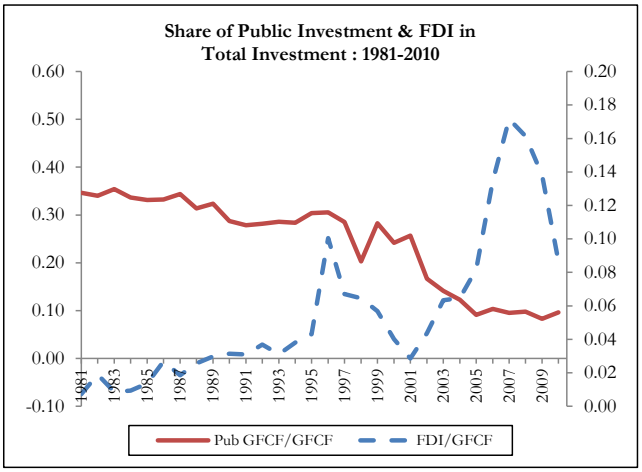

Share of Private Investment & FDI in
Total Investment : 1981-2010
Priv GFCF/GFCF
FDI/GFCF

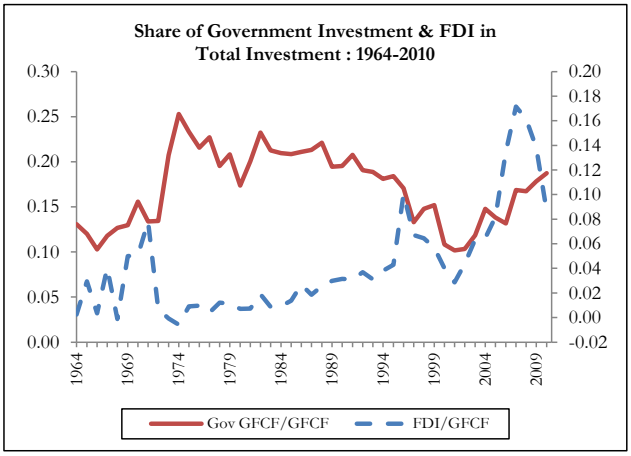

Share of Public Investment* & FDI in
Total Investment : 1964-2010
Public GFCF*/GFCF
FDI/GFCF

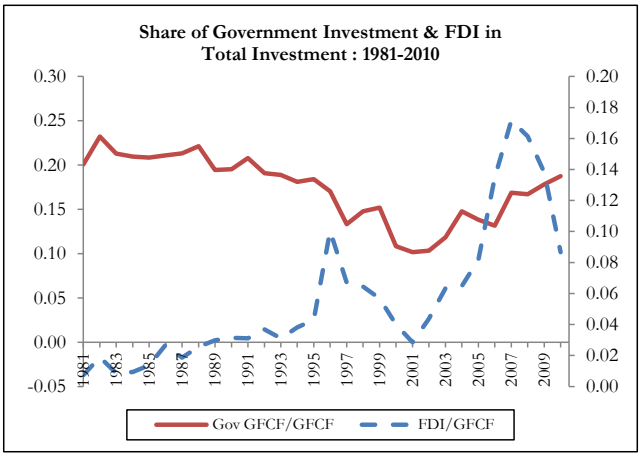

Share of Public Investment* & FDI in
Total Investment : 1981-2010
Public GFCF*/GFCF
FDI/GFCF

## Figure 2A (iii)

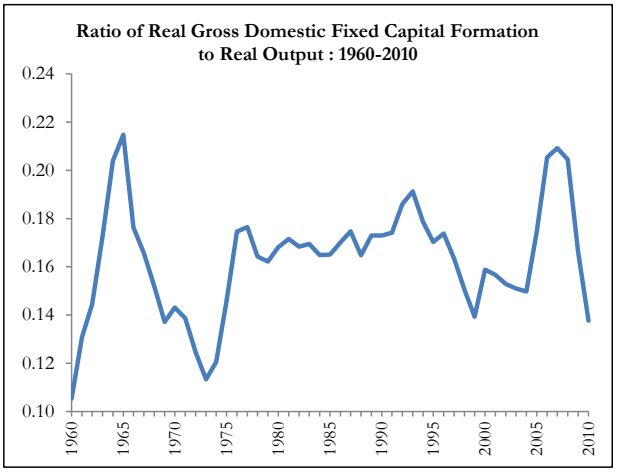


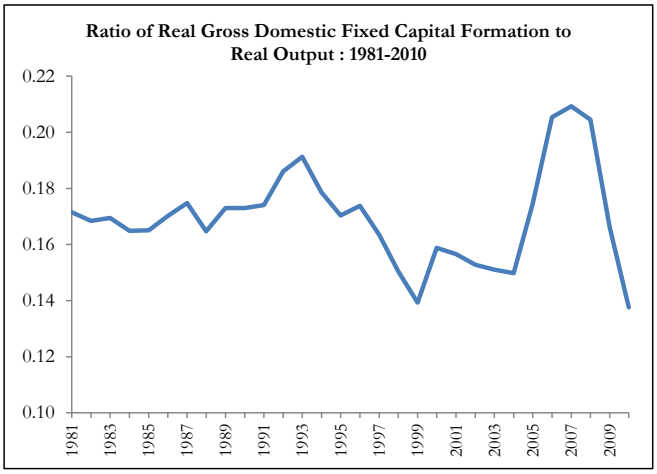



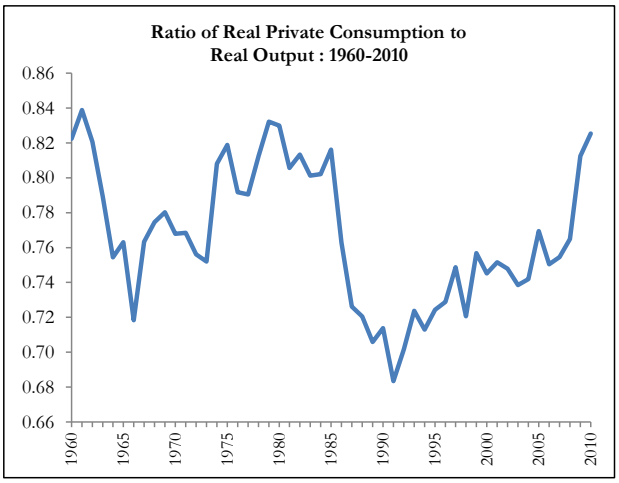



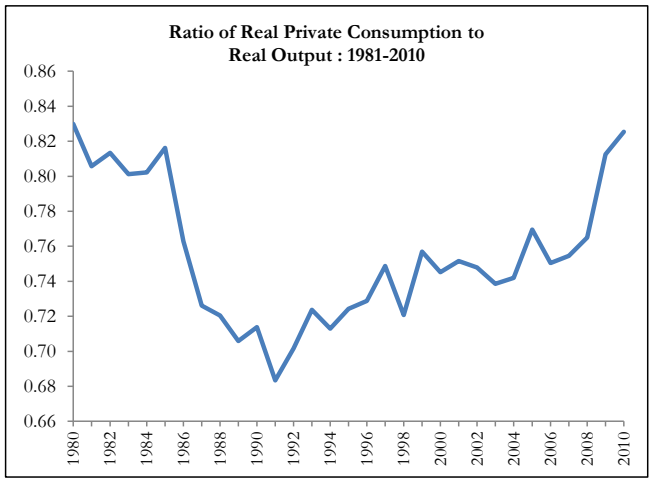



## Figure 2B (i)

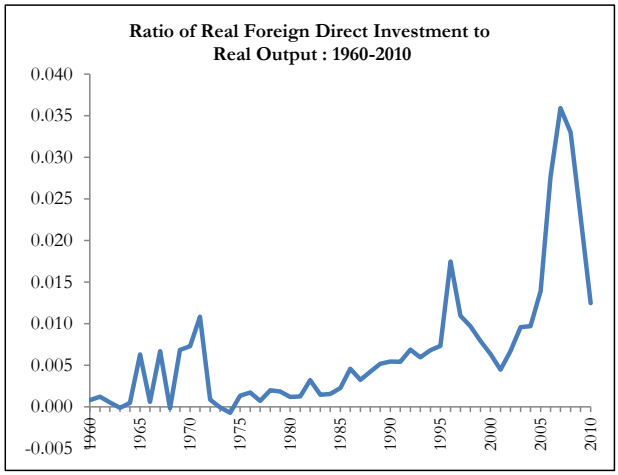

Ratio of Real Gross Domestic Fixed Capital Formation to Real Output : 1960-2010
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

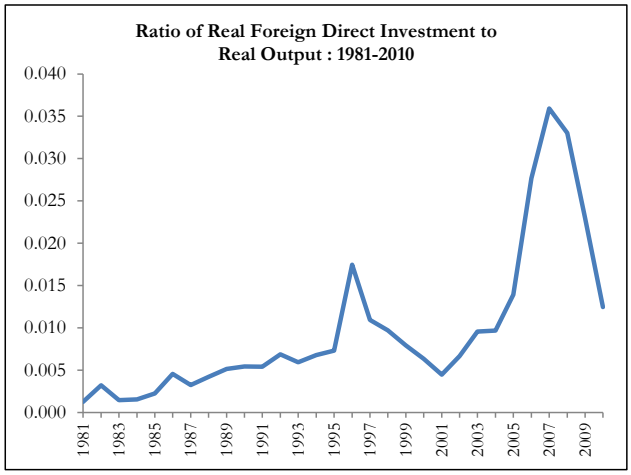

Ratio of Real Gross Domestic Fixed Capital Formation to Real Output : 1981-2010
0.22
0.20
0.18
0.16
0.14
0.12
0.10
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009

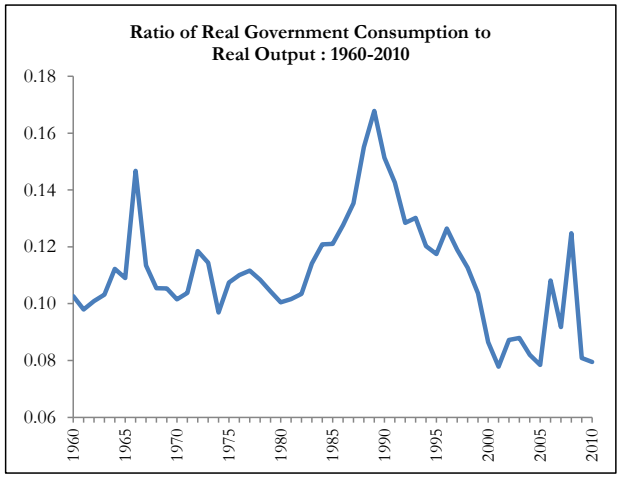

Ratio of Real Private Consumption to Real Output : 1960-2010
0.86
0.84
0.82
0.80
0.78
0.76
0.74
0.72
0.70
0.68
0.66
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

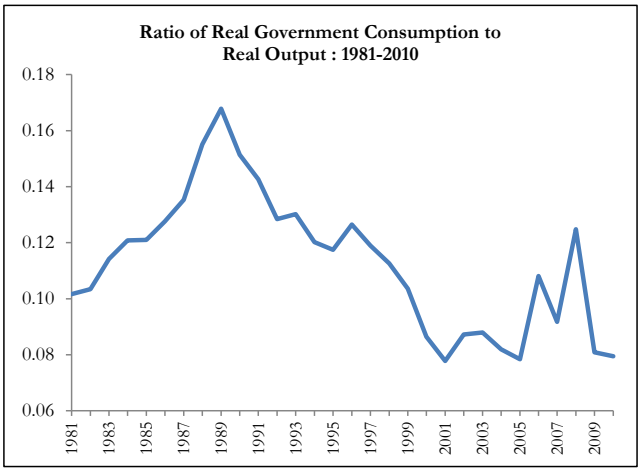

Ratio of Real Private Consumption to Real Output : 1981-2010
0.86
0.84
0.82
0.80
0.78
0.76
0.74
0.72
0.70
0.68
0.66
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010

## Figure 2B (ii)

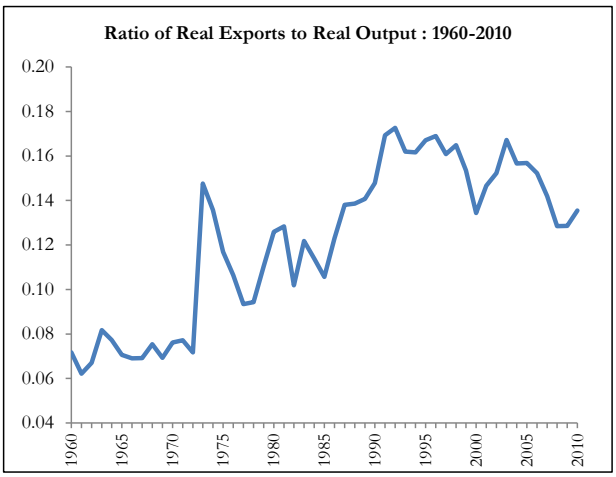

Ratio of Real Foreign Direct Investment to Real Output : 1960-2010
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-0.005
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

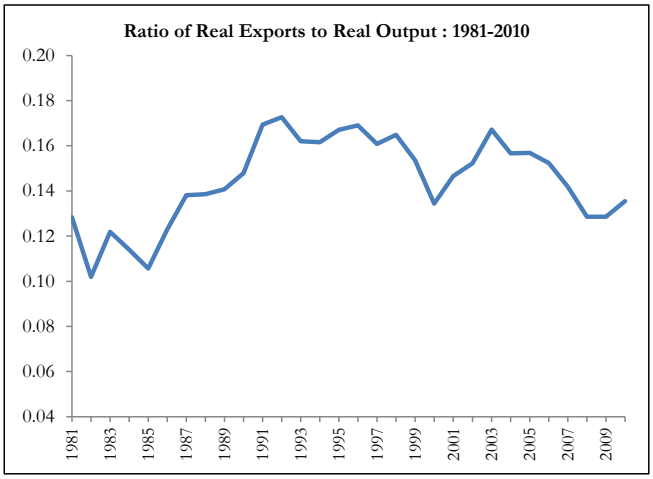

Ratio of Real Foreign Direct Investment to Real Output : 1981-2010
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009

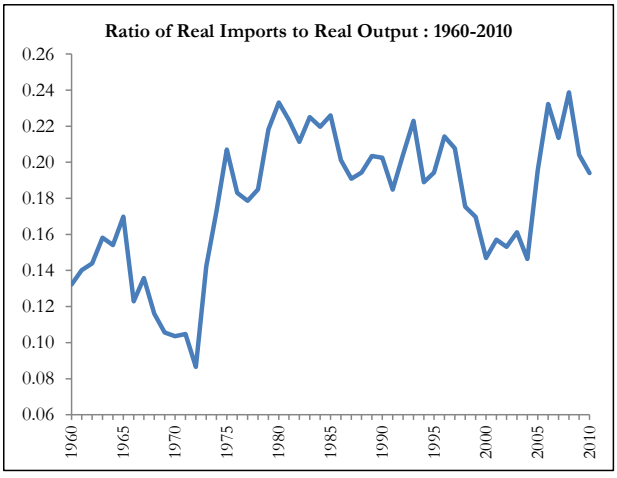

Ratio of Real Government Consumption to Real Output : 1960-2010
0.18
0.16
0.14
0.12
0.10
0.08
0.06
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

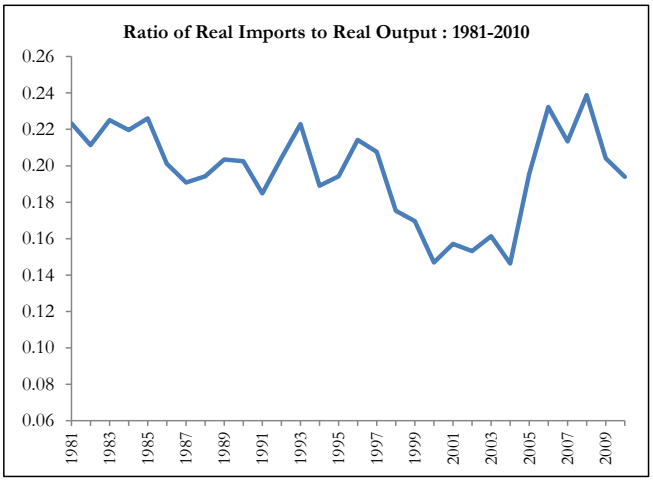

Ratio of Real Government Consumption to Real Output : 1981-2010
0.18
0.16
0.14
0.12
0.10
0.08
0.06
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009

## Figure 2B (iii)

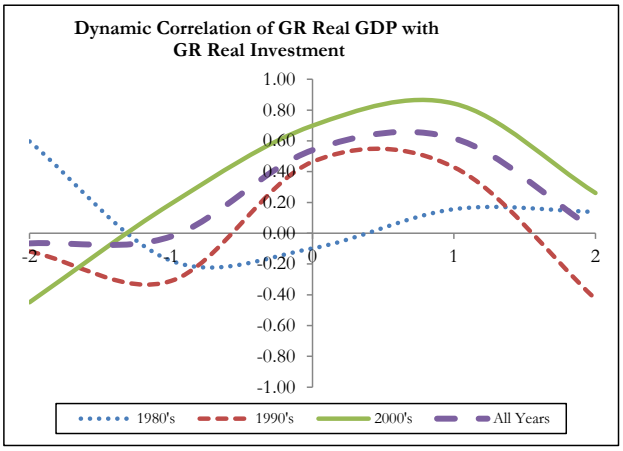


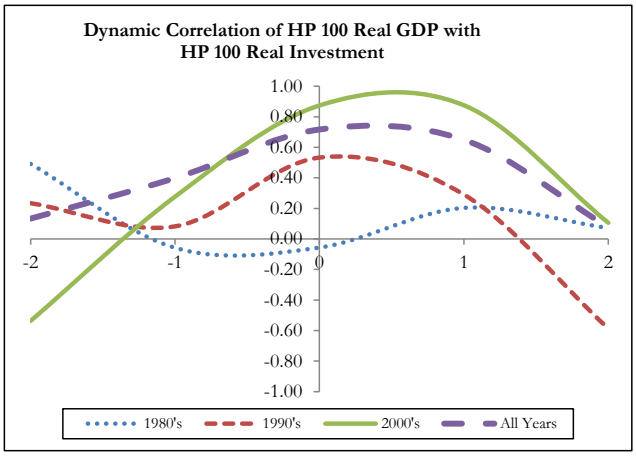



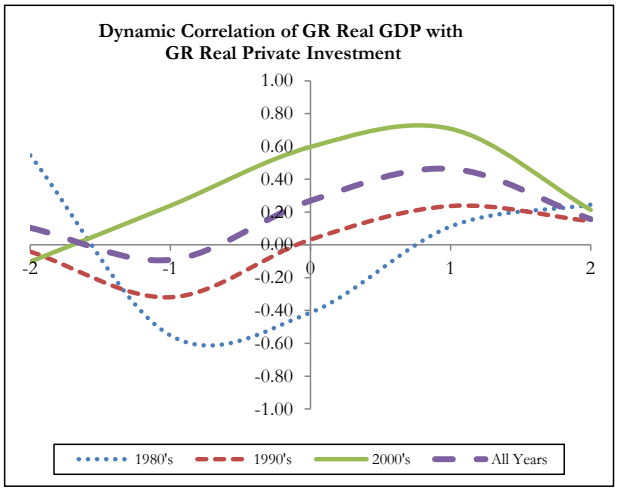



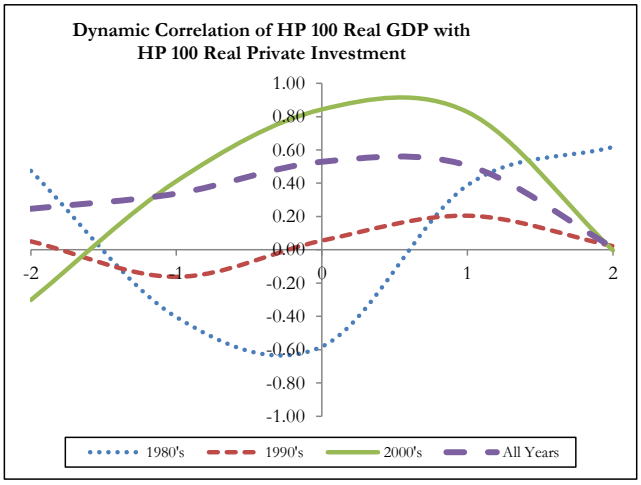



## Figure 3 (i)

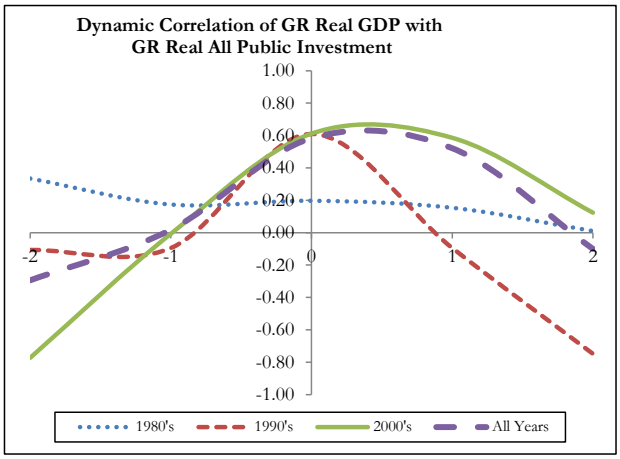

Dynamic Correlation of GR Real GDP with GR Real Investment
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

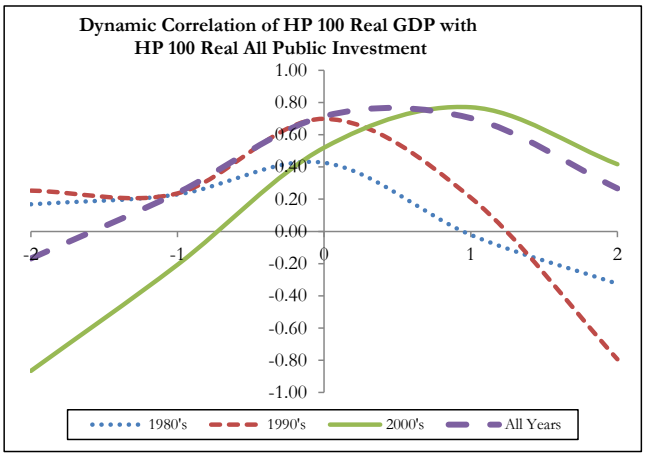

Dynamic Correlation of HP 100 Real GDP with HP 100 Real Investment
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

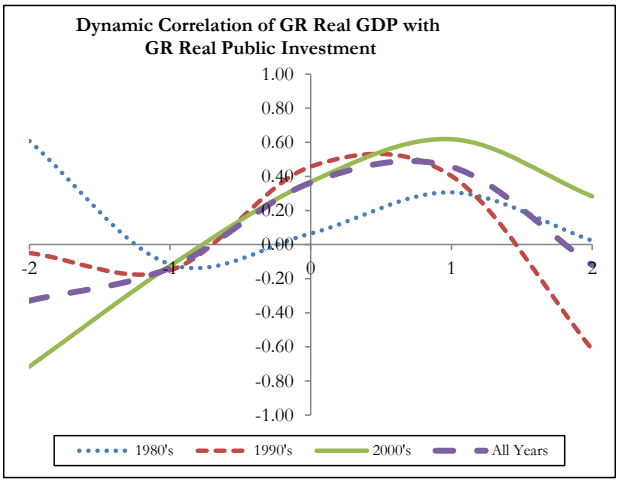

Dynamic Correlation of GR Real GDP with GR Real Private Investment
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

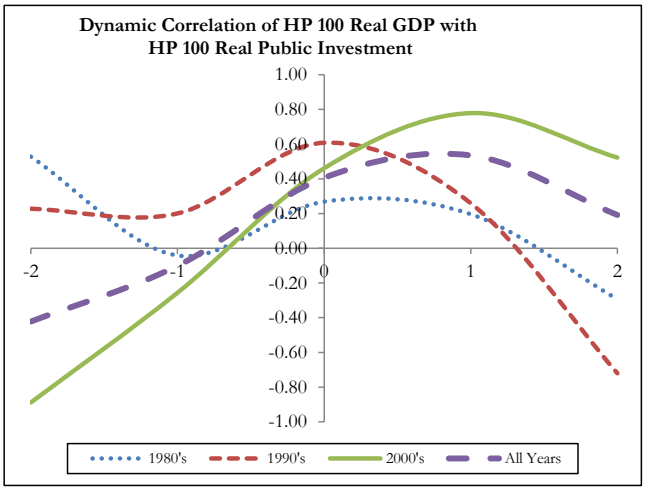

Dynamic Correlation of HP 100 Real GDP with HP 100 Real Private Investment
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

## Figure 3 (ii)

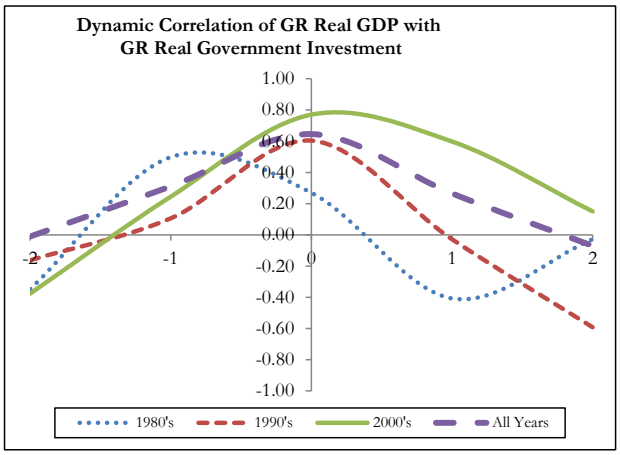

Dynamic Correlation of GR Real GDP with
GR Real All Public Investment
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

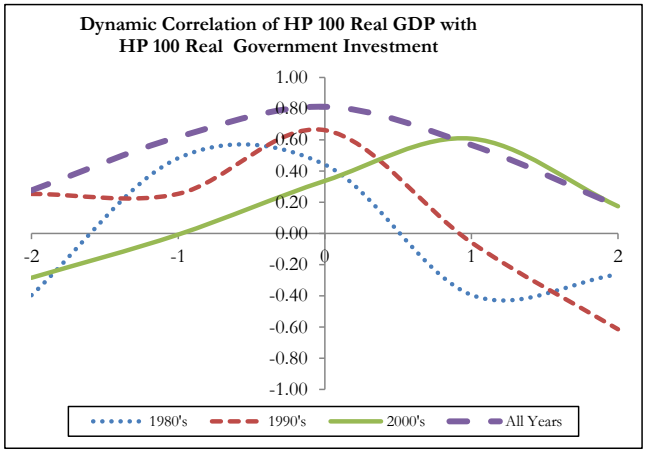

Dynamic Correlation of HP 100 Real GDP with
HP 100 Real All Public Investment
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years


Dynamic Correlation of GR Real GDP with
GR Real Public Investment
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

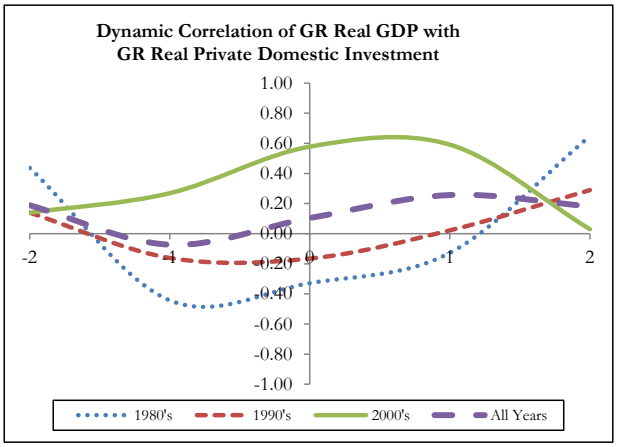

Dynamic Correlation of HP 100 Real GDP with
HP 100 Real Public Investment
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

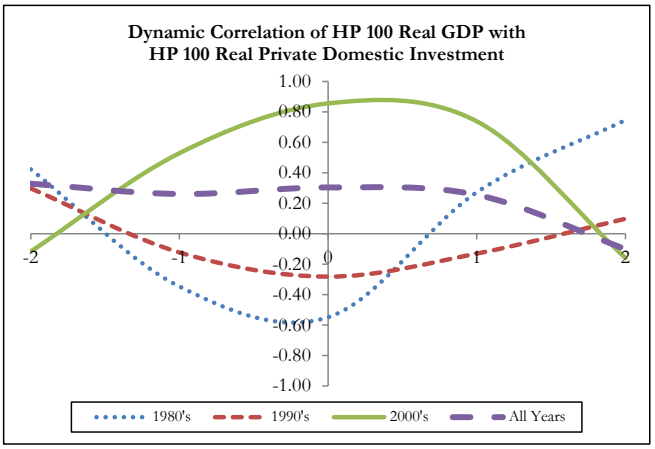
## Figure 3 (iii)

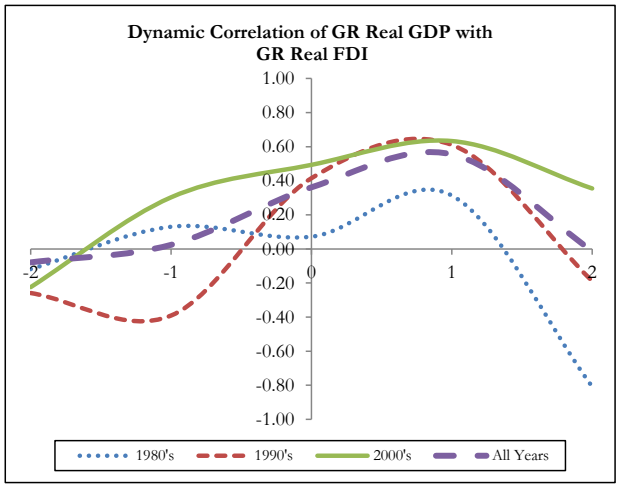

Dynamic Correlation of GR Real GDP with
GR Real Government Investment
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

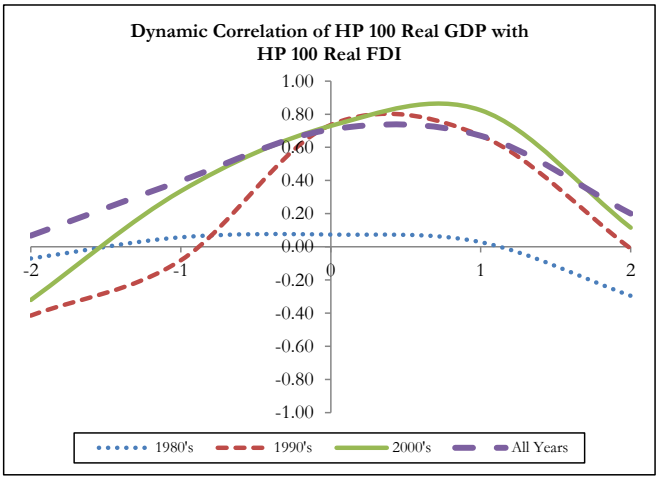

Dynamic Correlation of HP 100 Real GDP with
HP 100 Real Government Investment
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

## Figure 3 (iv)

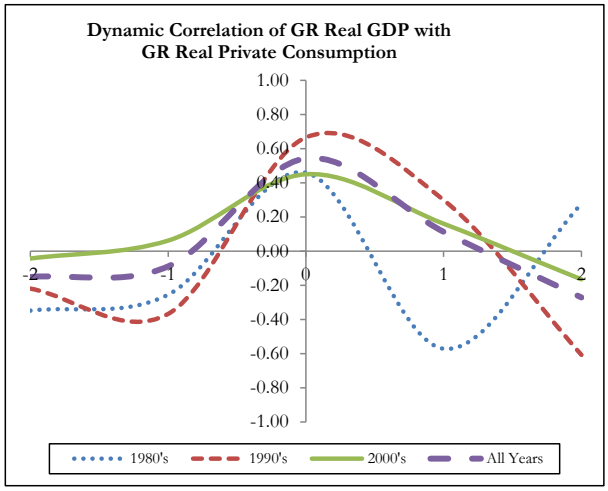

Dynamic Correlation of GR Real GDP with
GR Real Private Domestic Investment
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

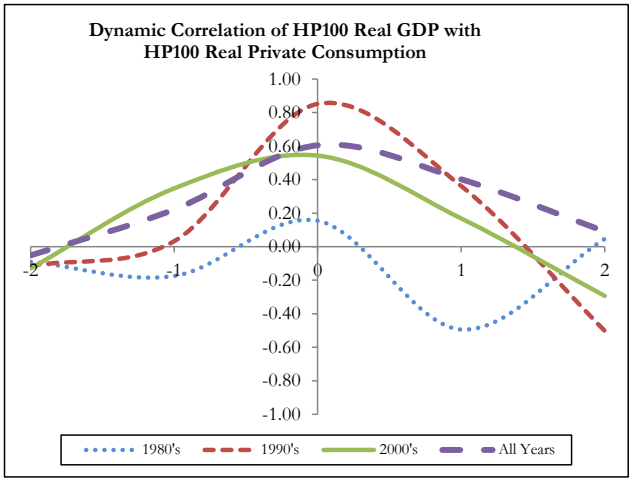

Dynamic Correlation of HP 100 Real GDP with
HP 100 Real Private Domestic Investment
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

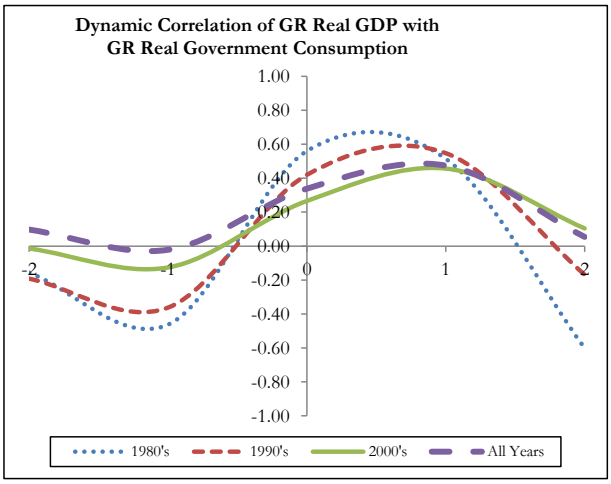

Dynamic Correlation of GR Real GDP with
GR Real FDI
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

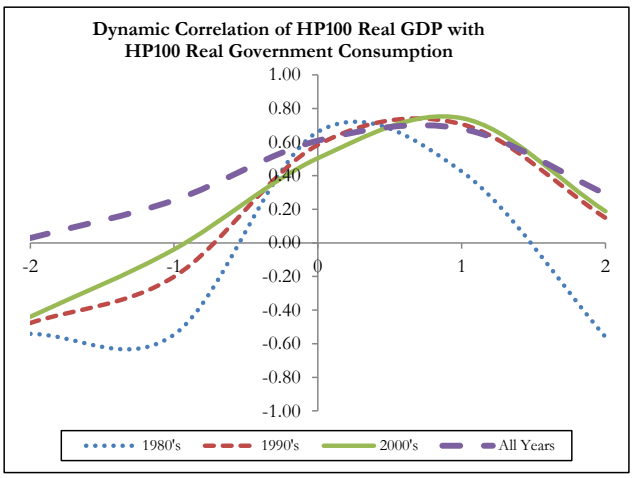

Dynamic Correlation of HP 100 Real GDP with
HP 100 Real FDI
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

## Figure 4 (i)

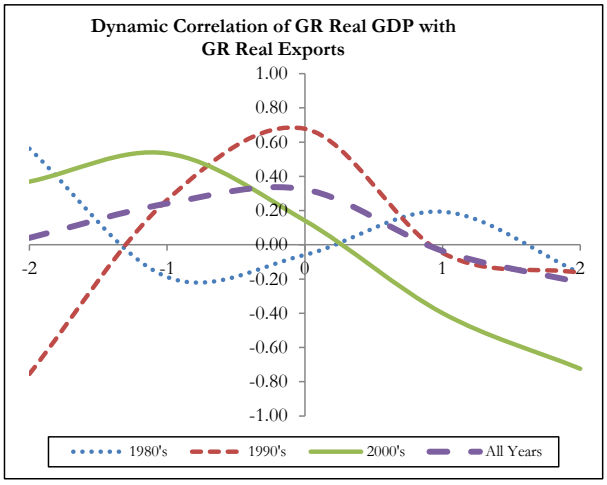

Dynamic Correlation of GR Real GDP with
GR Real Private Consumption
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

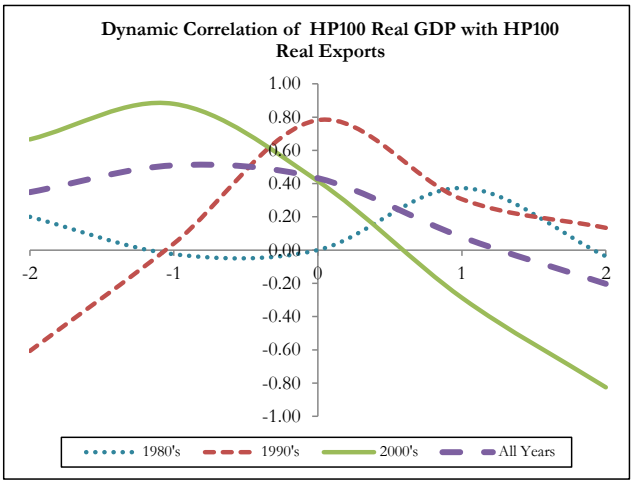

Dynamic Correlation of HP100 Real GDP with
HP100 Real Private Consumption
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

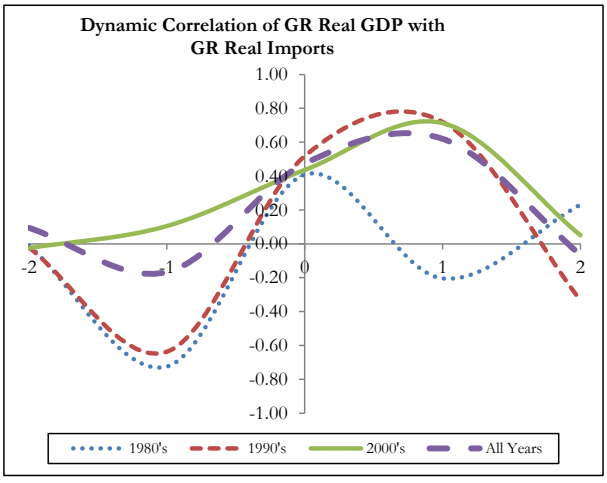

Dynamic Correlation of GR Real GDP with
GR Real Government Consumption
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

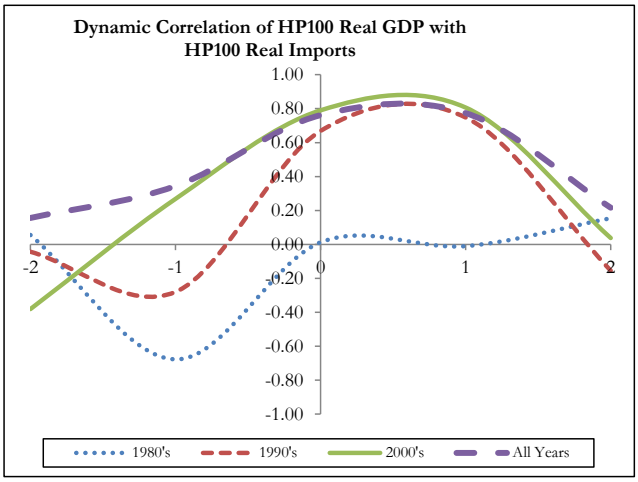

Dynamic Correlation of HP100 Real GDP with
HP100 Real Government Consumption
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

## Figure 4 (ii)

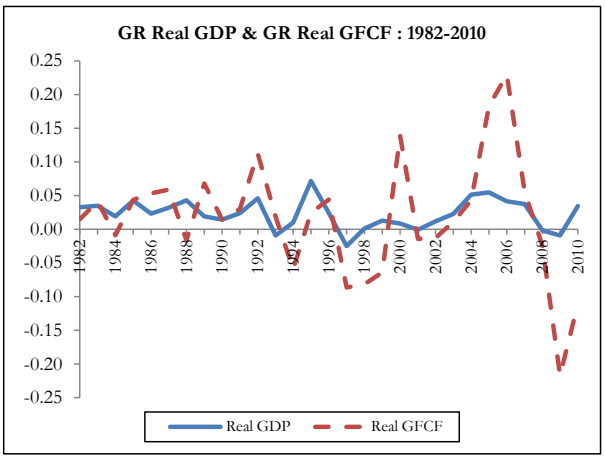

Dynamic Correlation of GR Real GDP with GR Real Exports
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

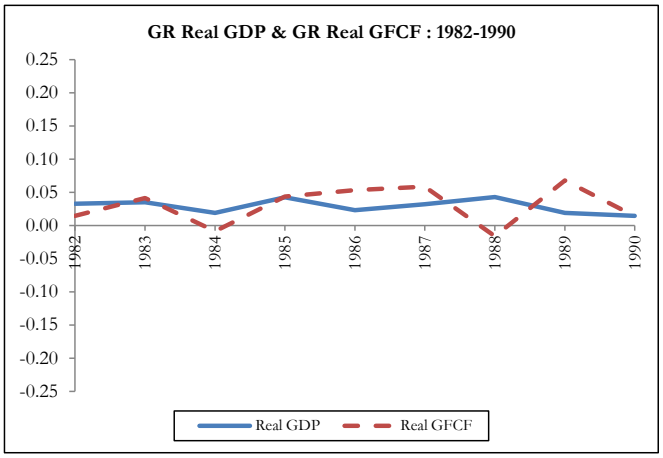

Dynamic Correlation of HP100 Real GDP with HP100 Real Exports
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

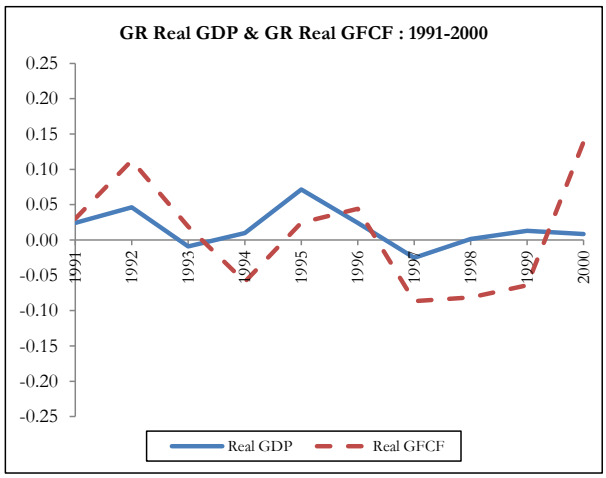

Dynamic Correlation of GR Real GDP with GR Real Imports
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

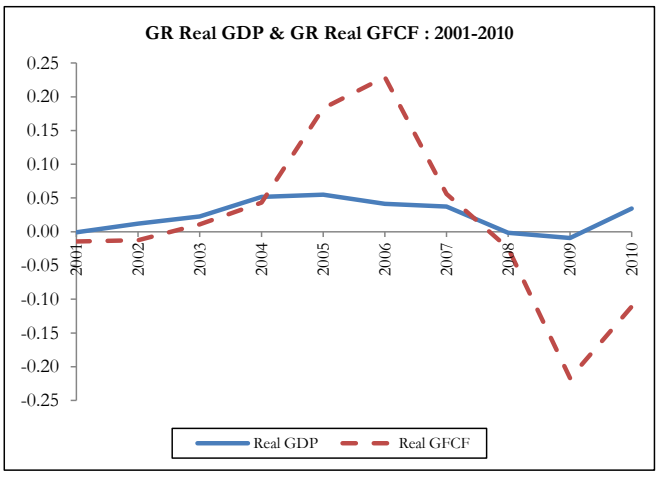

Dynamic Correlation of HP100 Real GDP with HP100 Real Imports
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-2
-1
0
1
2
1980's
1990's
2000's
All Years

## Figure 5 (i)

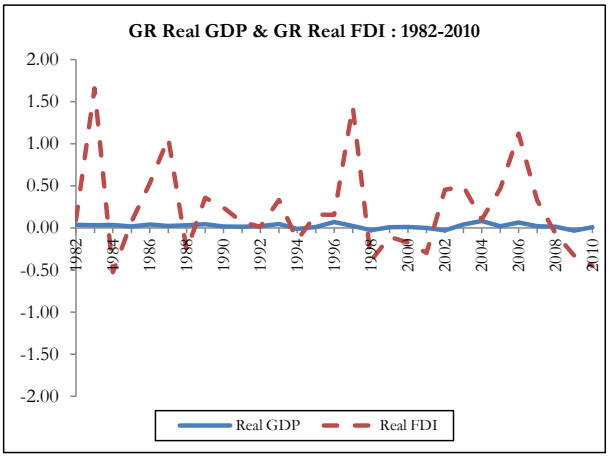

GR Real GDP & GR Real GFCF : 1982-2010
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Real GDP
Real GFCF

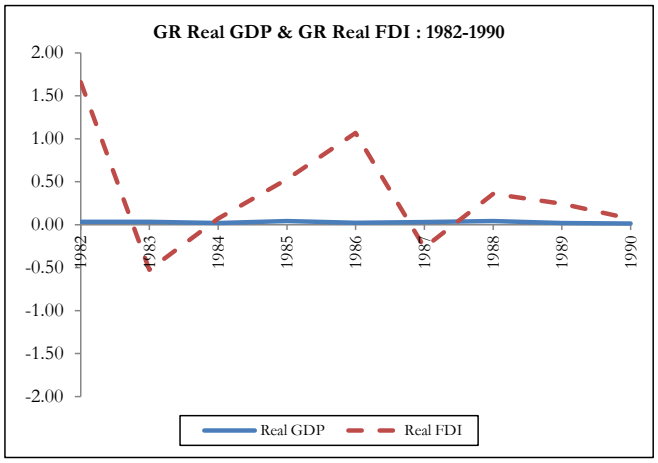

GR Real GDP & GR Real GFCF : 1982-1990
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
1982
1983
1984
1985
1986
1987
1988
1989
1990
Real GDP
Real GFCF

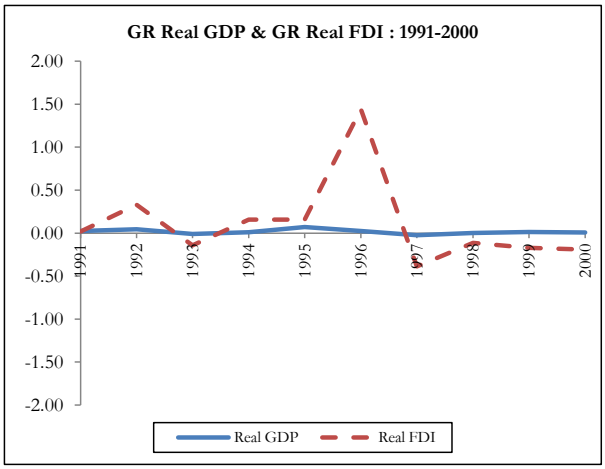

GR Real GDP & GR Real GFCF : 1991-2000
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Real GDP
Real GFCF

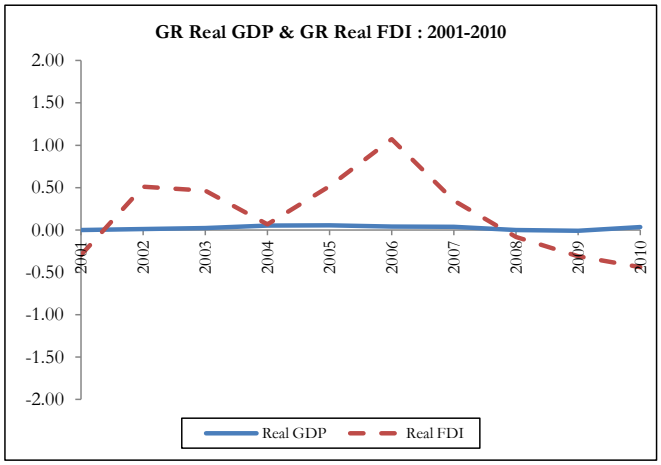

GR Real GDP & GR Real GFCF : 2001-2010
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Real GDP
Real GFCF

## Figure 5 (ii)

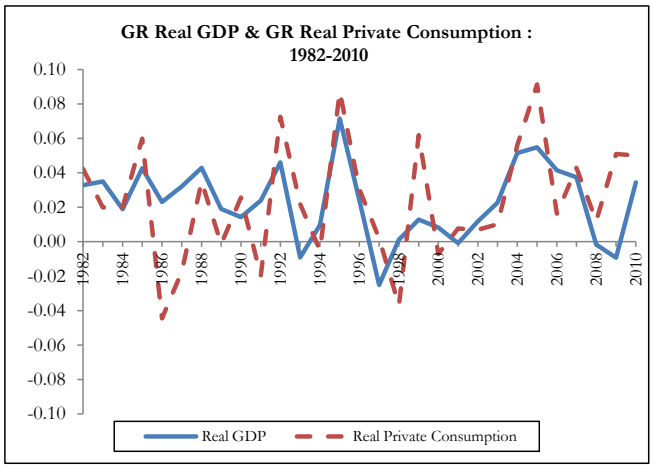

GR Real GDP & GR Real FDI : 1982-2010
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Real GDP
Real FDI

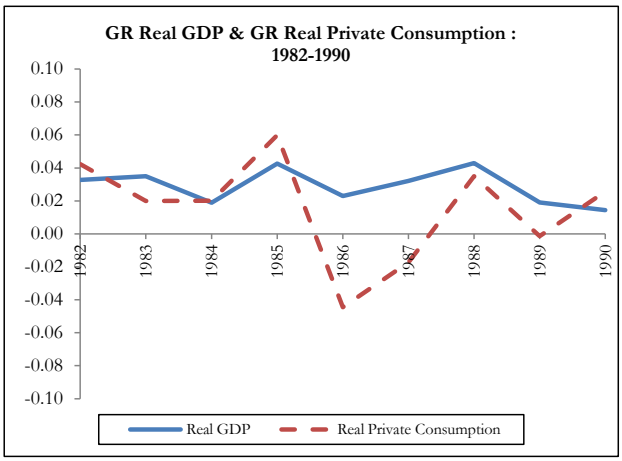

GR Real GDP & GR Real FDI : 1982-1990
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
1982
1983
1984
1985
1986
1987
1988
1989
1990
Real GDP
Real FDI

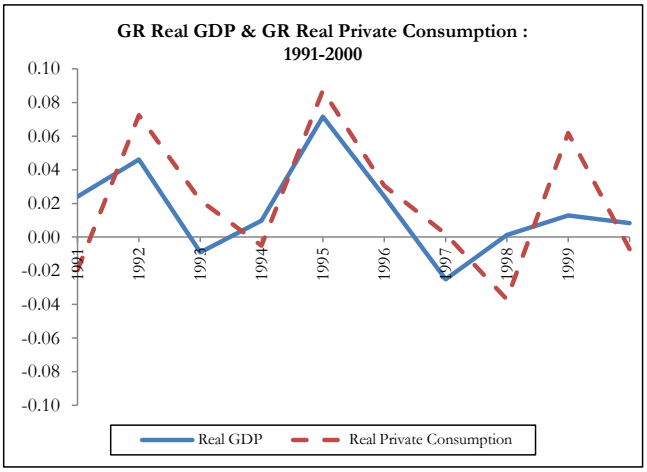

GR Real GDP & GR Real FDI : 1991-2000
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Real GDP
Real FDI

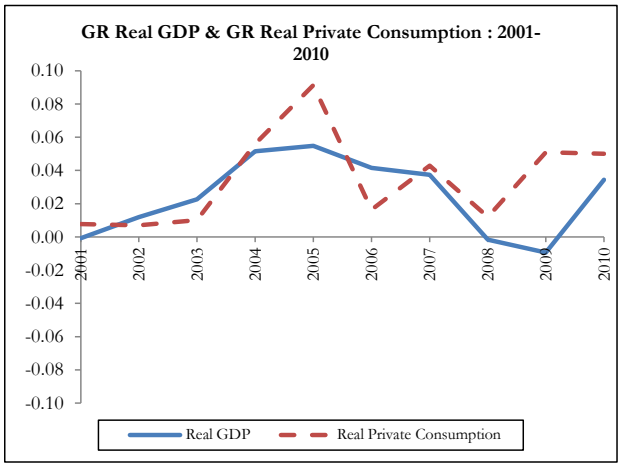

GR Real GDP & GR Real FDI : 2001-2010
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Real GDP
Real FDI

## Figure 5 (iii)

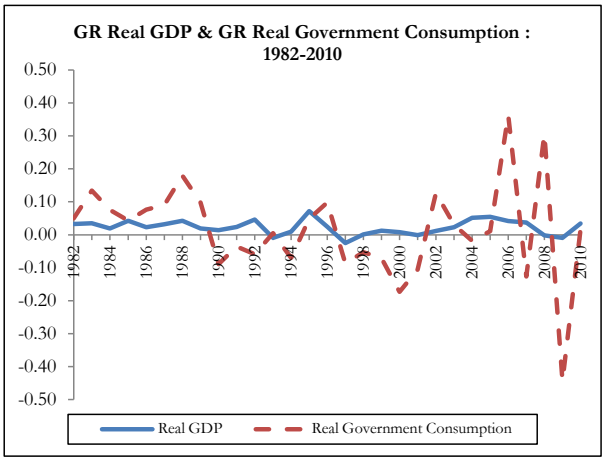

GR Real GDP & GR Real Private Consumption : 1982-2010
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Real GDP
Real Private Consumption

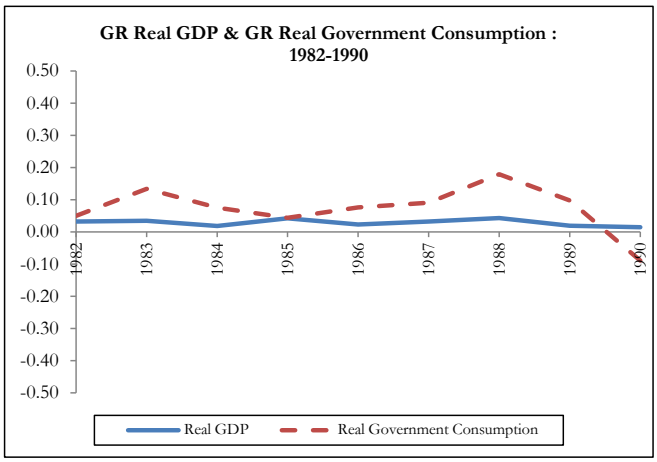

GR Real GDP & GR Real Private Consumption : 1982-1990
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
1982
1983
1984
1985
1986
1987
1988
1989
1990
Real GDP
Real Private Consumption

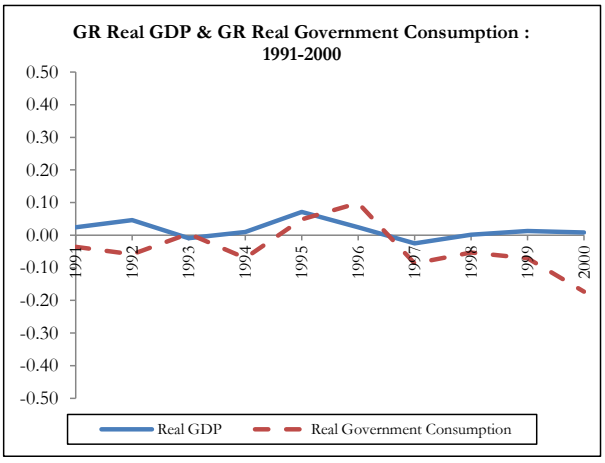

GR Real GDP & GR Real Private Consumption : 1991-2000
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
1991
1992
1993
1994
1995
1996
1997
1998
1999
Real GDP
Real Private Consumption

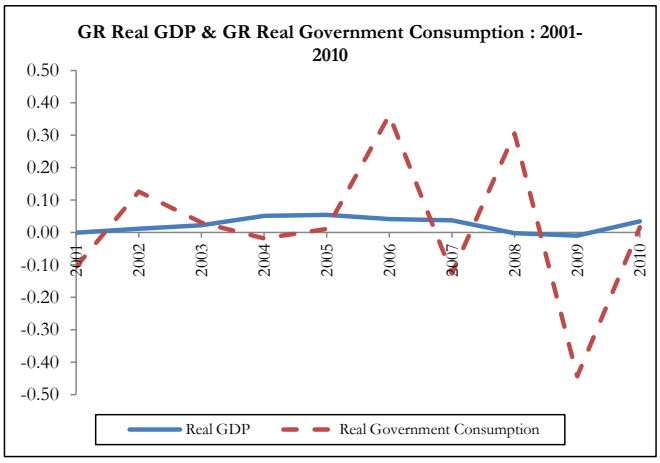

GR Real GDP & GR Real Private Consumption : 2001-2010
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Real GDP
Real Private Consumption

## Figure 5 (iv)

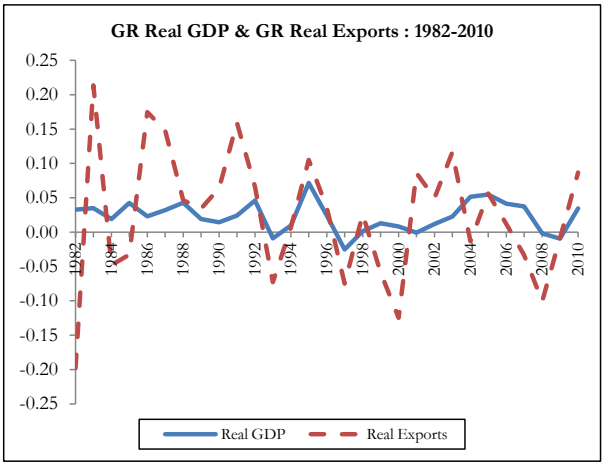

GR Real GDP & GR Real Government Consumption : 1982-2010
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Real GDP
Real Government Consumption

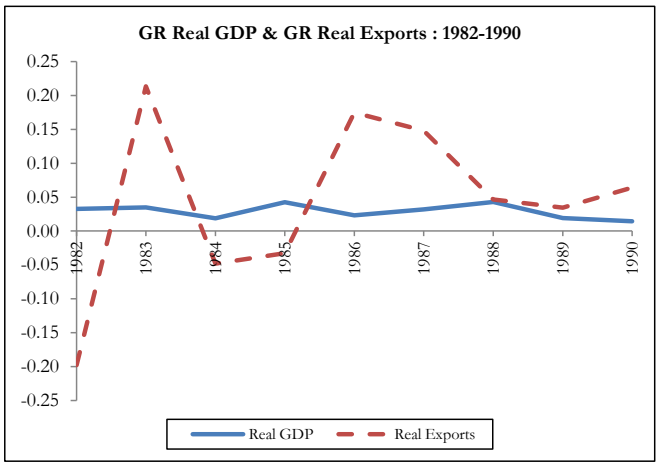

GR Real GDP & GR Real Government Consumption : 1982-1990
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
1982
1983
1984
1985
1986
1987
1988
1989
1990
Real GDP
Real Government Consumption

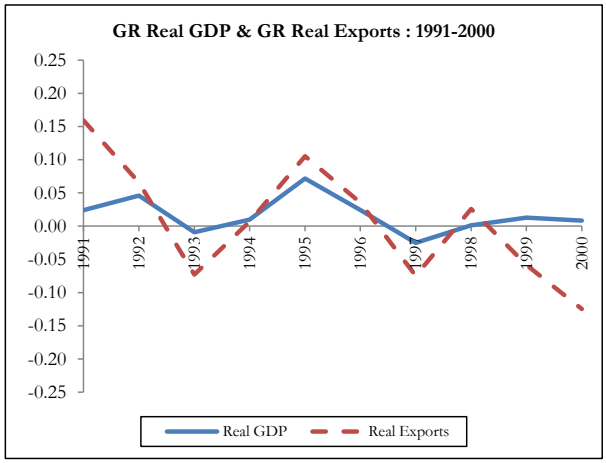

GR Real GDP & GR Real Government Consumption : 1991-2000
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Real GDP
Real Government Consumption

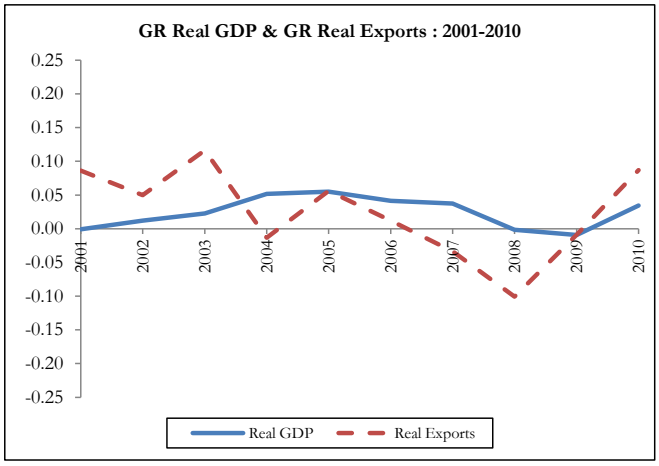

GR Real GDP & GR Real Government Consumption : 2001-2010
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Real GDP
Real Government Consumption

## Figure 5 (v)

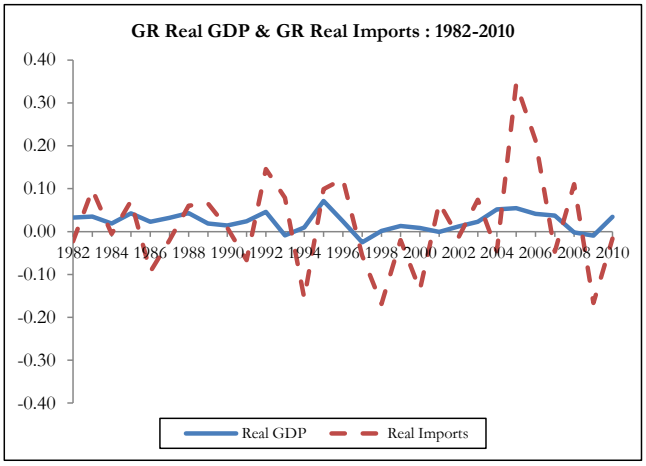

GR Real GDP & GR Real Exports : 1982-2010
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Real GDP
Real Exports

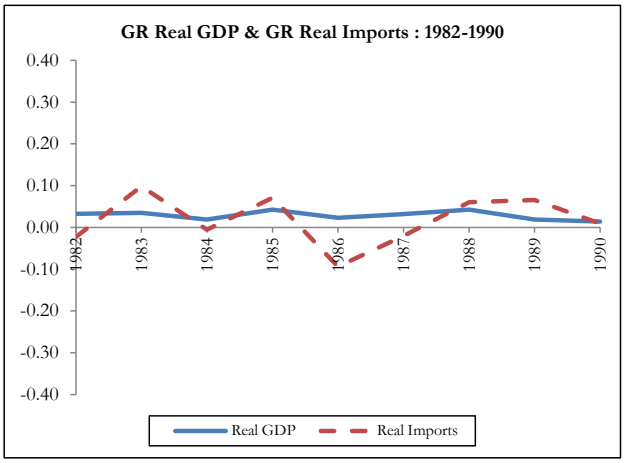

GR Real GDP & GR Real Exports : 1982-1990
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
1982
1983
1984
1985
1986
1987
1988
1989
1990
Real GDP
Real Exports

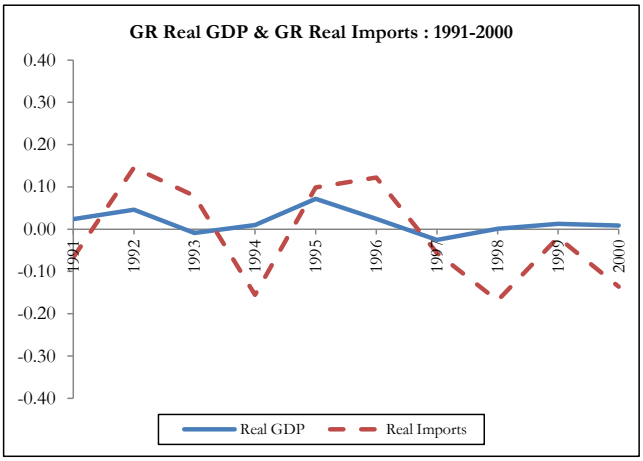

GR Real GDP & GR Real Exports : 1991-2000
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Real GDP
Real Exports

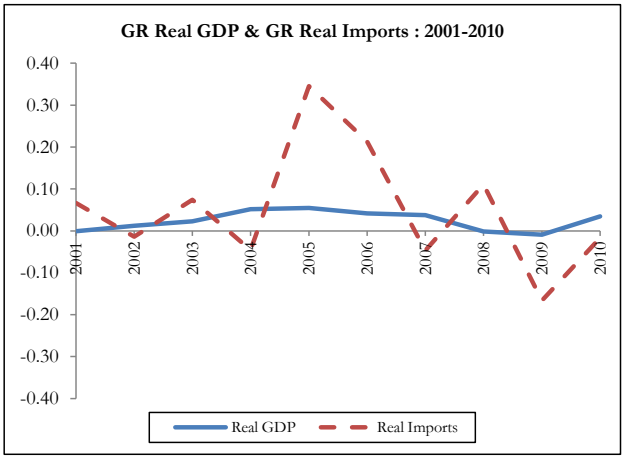

GR Real GDP & GR Real Exports : 2001-2010
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Real GDP
Real Exports

## Figure 5 (vi)

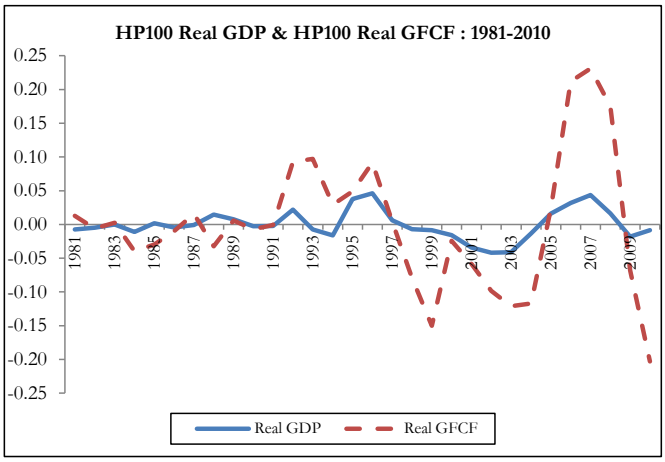

GR Real GDP & GR Real Imports : 1982-2010
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010
Real GDP
Real Imports

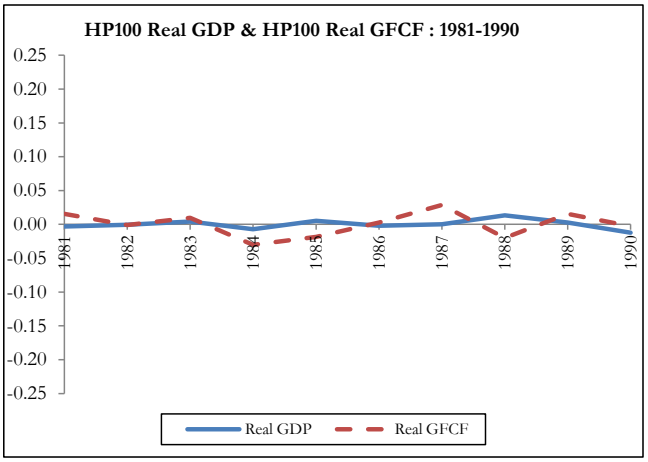

GR Real GDP & GR Real Imports : 1982-1990
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
1982
1983
1984
1985
1986
1987
1988
1989
1990
Real GDP
Real Imports

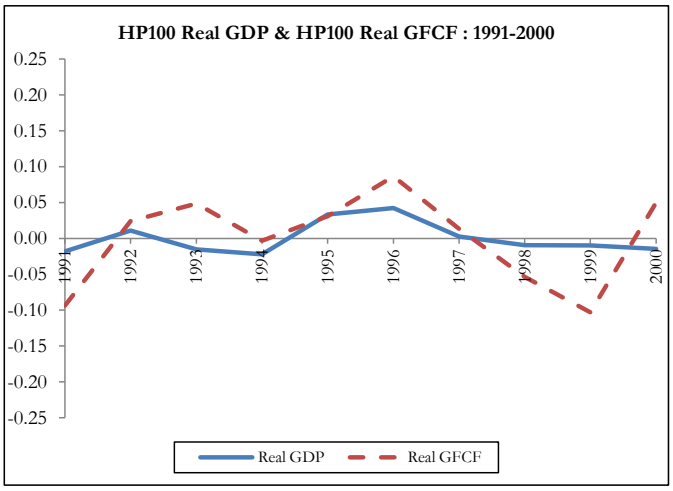

GR Real GDP & GR Real Imports : 1991-2000
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
1991
1992
1993
1994
1995
1996
1998
1999
2000
Real GDP
Real Imports

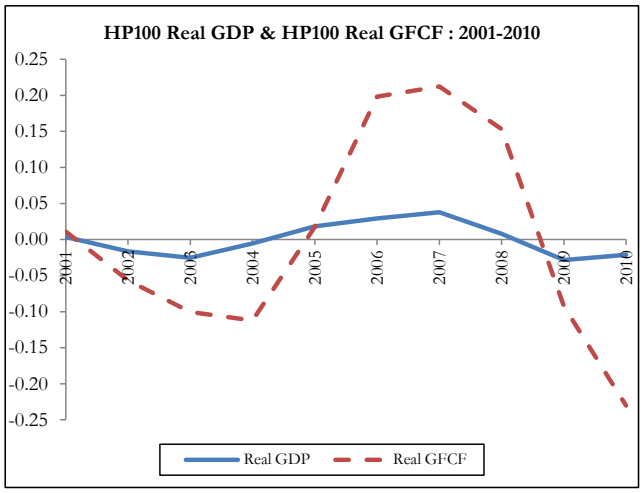

GR Real GDP & GR Real Imports : 2001-2010
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Real GDP
Real Imports

## Figure 6 (i)

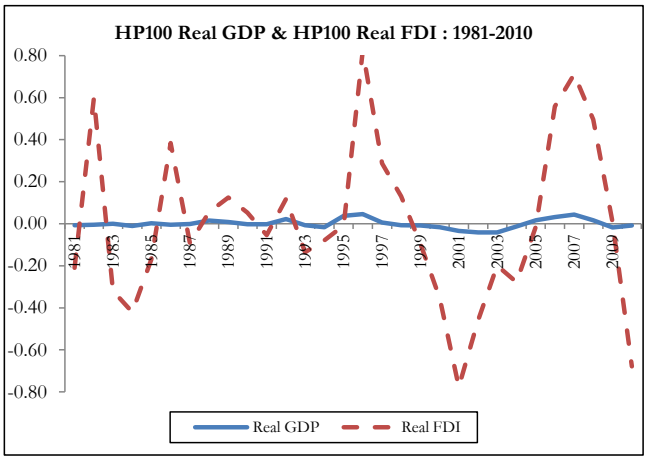

HP100 Real GDP & HP100 Real GFCF : 1981-2010
Real GDP
Real GFCF

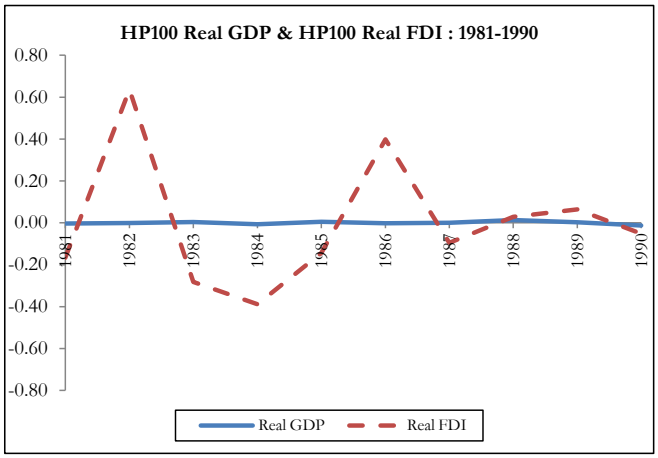

HP100 Real GDP & HP100 Real GFCF : 1981-1990
Real GDP
Real GFCF

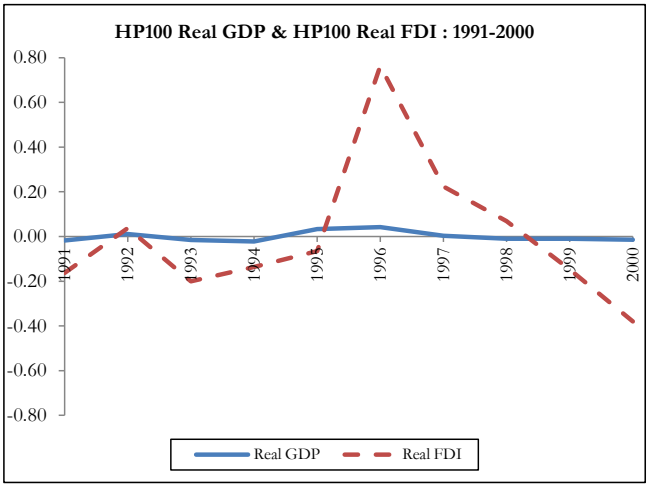

HP100 Real GDP & HP100 Real GFCF : 1991-2000
Real GDP
Real GFCF

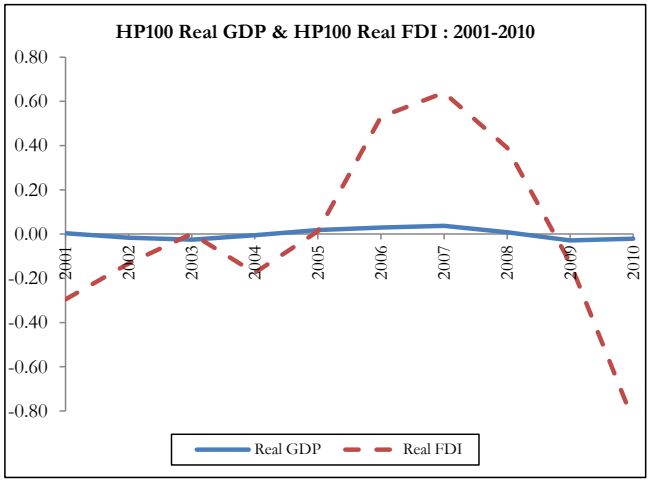

HP100 Real GDP & HP100 Real GFCF : 2001-2010
Real GDP
Real GFCF

## Figure 6 (ii)

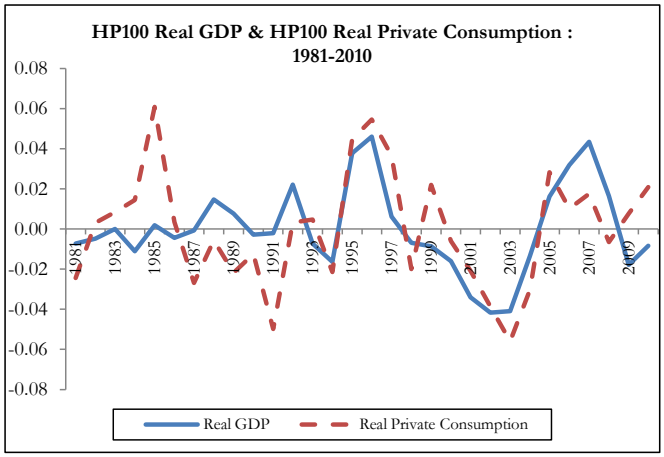

HP100 Real GDP & HP100 Real FDI : 1981-2010
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Real GDP
Real FDI

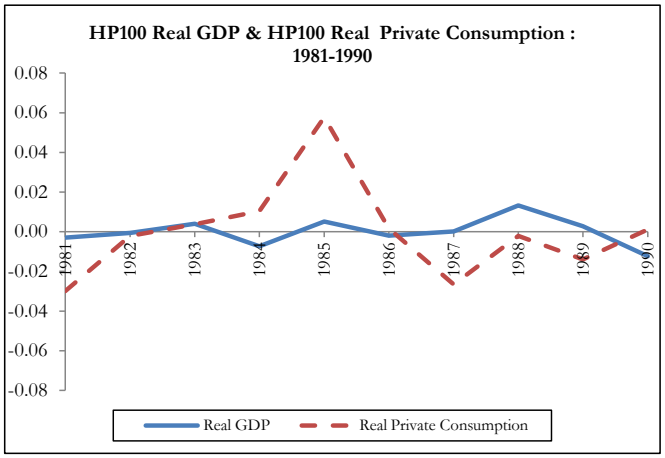

HP100 Real GDP & HP100 Real FDI : 1981-1990
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
Real GDP
Real FDI

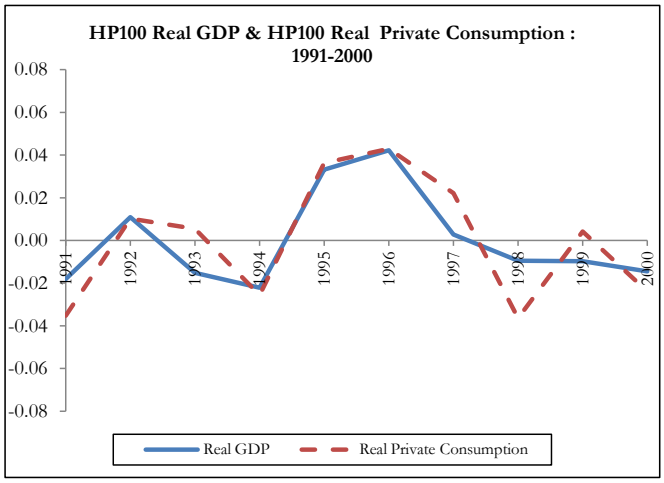

HP100 Real GDP & HP100 Real FDI : 1991-2000
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Real GDP
Real FDI

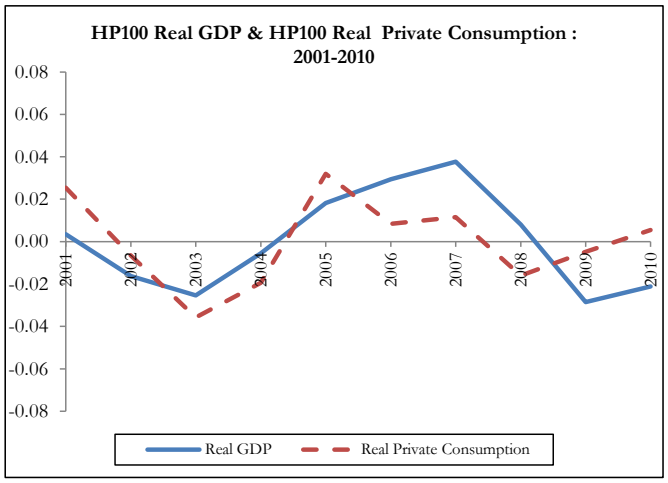

HP100 Real GDP & HP100 Real FDI : 2001-2010
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Real GDP
Real FDI

## Figure 6 (iii)

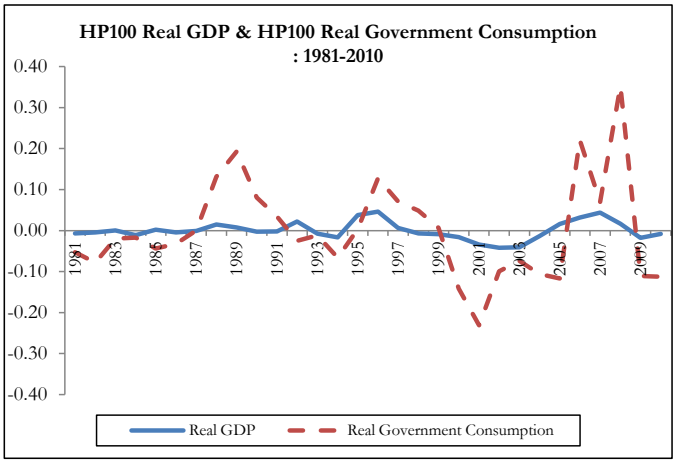

HP100 Real GDP & HP100 Real Private Consumption : 1981-2010
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Real GDP
Real Private Consumption

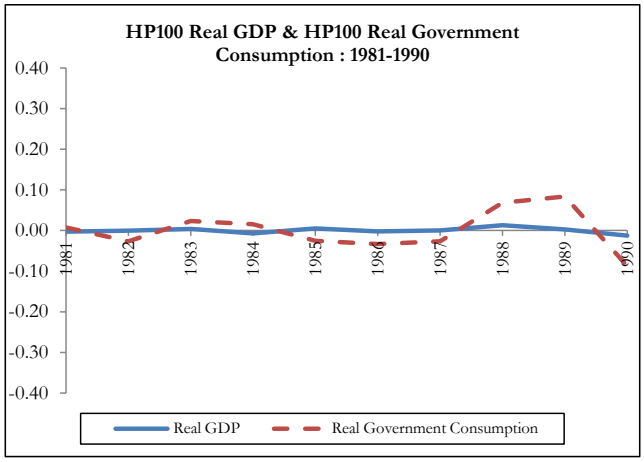

HP100 Real GDP & HP100 Real Private Consumption : 1981-1990
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
Real GDP
Real Private Consumption

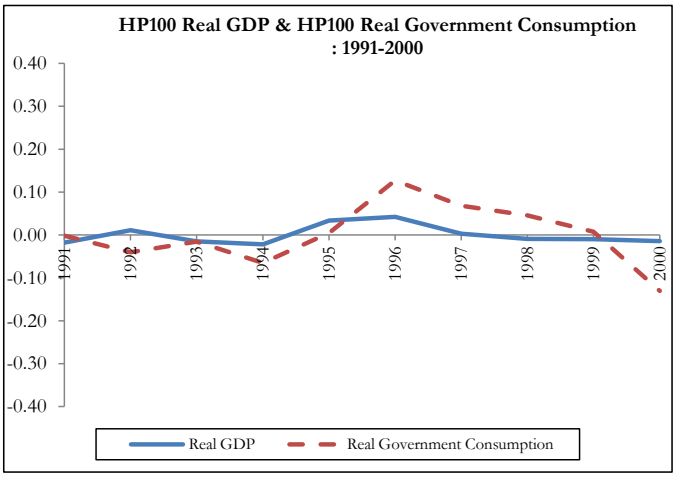

HP100 Real GDP & HP100 Real Private Consumption : 1991-2000
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Real GDP
Real Private Consumption

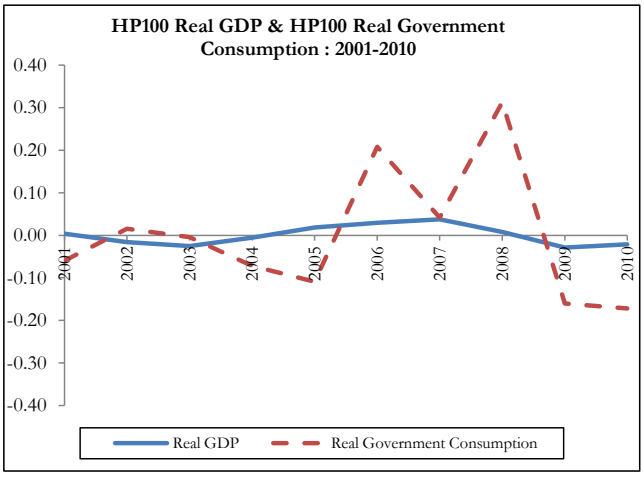

HP100 Real GDP & HP100 Real Private Consumption : 2001-2010
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Real GDP
Real Private Consumption

## Figure 6 (iv)

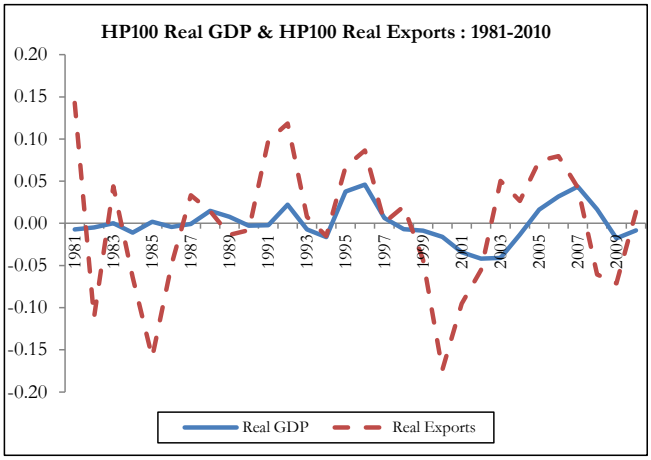

HP100 Real GDP & HP100 Real Government Consumption : 1981-2010
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Real GDP
Real Government Consumption

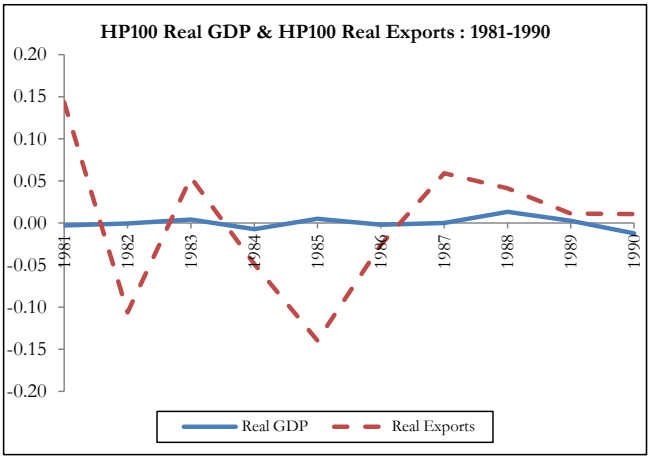

HP100 Real GDP & HP100 Real Government Consumption : 1981-1990
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
Real GDP
Real Government Consumption

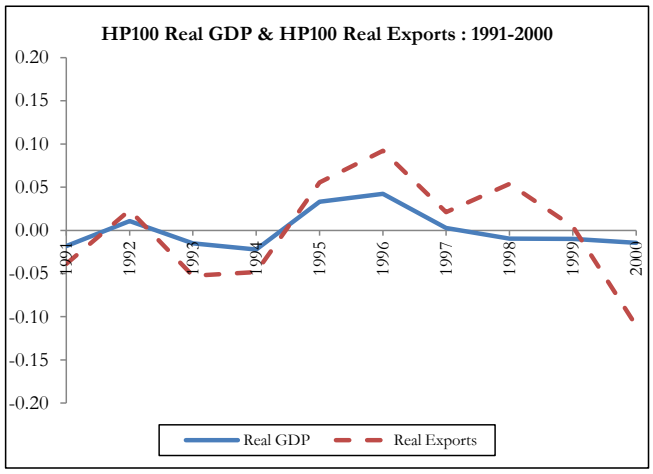

HP100 Real GDP & HP100 Real Government Consumption : 1991-2000
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Real GDP
Real Government Consumption

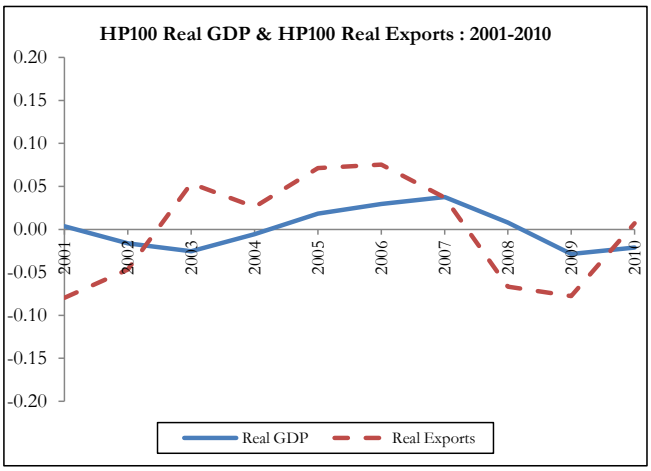

HP100 Real GDP & HP100 Real Government Consumption : 2001-2010
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Real GDP
Real Government Consumption

## Figure 6 (v)

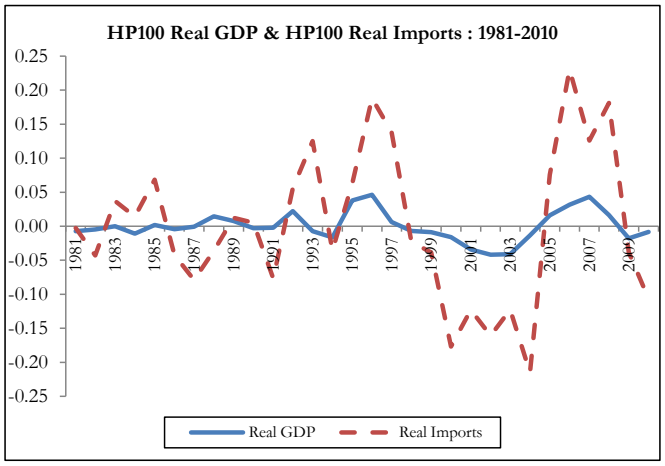

HP100 Real GDP & HP100 Real Exports : 1981-2010
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Real GDP
Real Exports

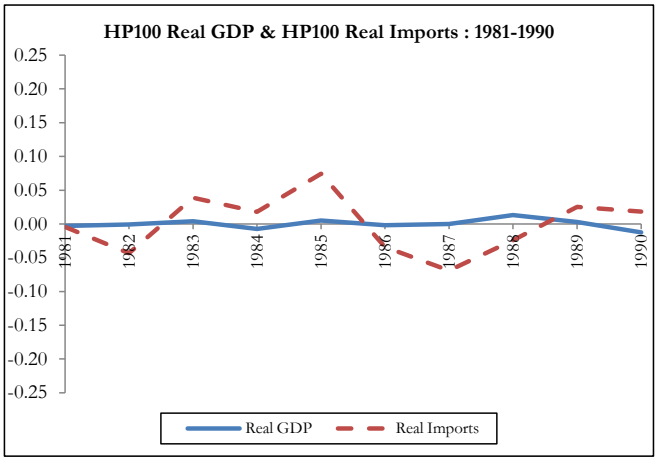

HP100 Real GDP & HP100 Real Exports : 1981-1990
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
Real GDP
Real Exports

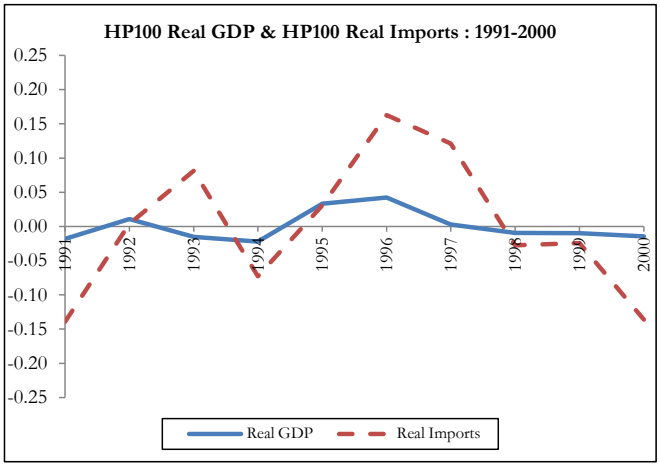

HP100 Real GDP & HP100 Real Exports : 1991-2000
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Real GDP
Real Exports


HP100 Real GDP & HP100 Real Exports : 2001-2010
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Real GDP
Real Exports

## Figure 6 (vi)


HP100 Real GDP & HP100 Real Imports : 1981-2010
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Real GDP
Real Imports


HP100 Real GDP & HP100 Real Imports : 1981-1990
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
Real GDP
Real Imports


HP100 Real GDP & HP100 Real Imports : 1991-2000
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Real GDP
Real Imports

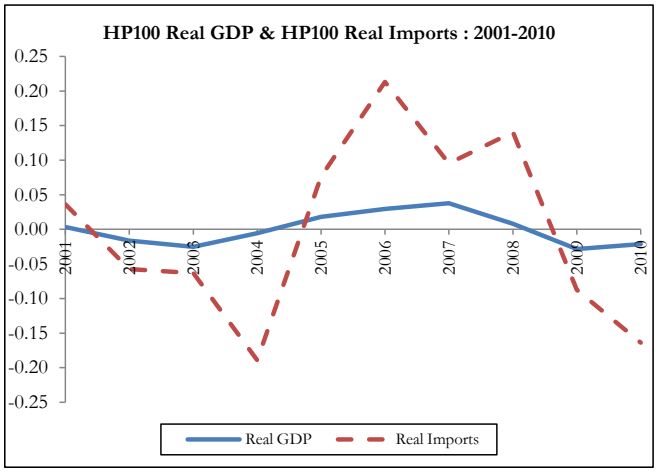

HP100 Real GDP & HP100 Real Imports : 2001-2010
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Real GDP
Real Imports

**Figure 7**

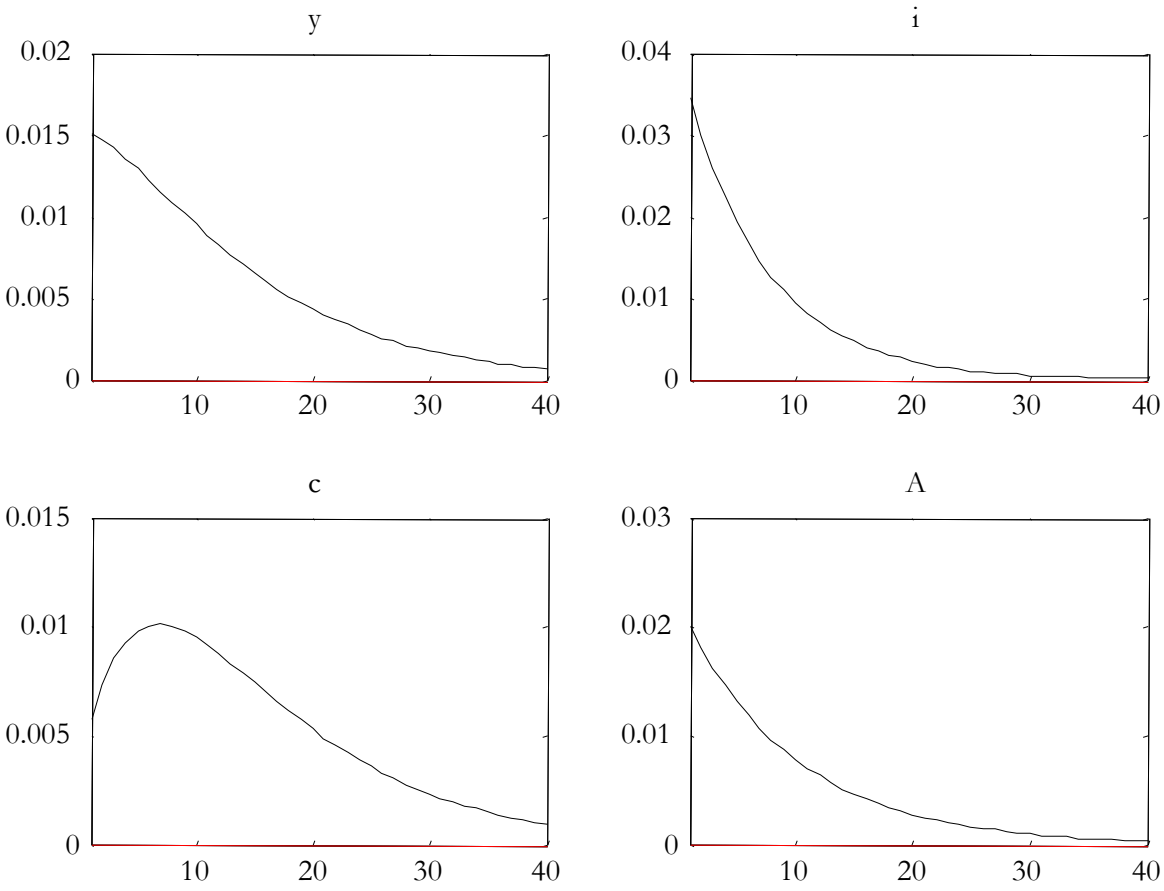

y
0.02
0.015
0.01
0.005
0
10
20
30
40
i
0.04
0.03
0.02
0.01
0
10
20
30
40
c
0.015
0.01
0.005
0
10
20
30
40
A
0.03
0.02
0.01
0
10
20
30
40

**Figure 8 (i)**

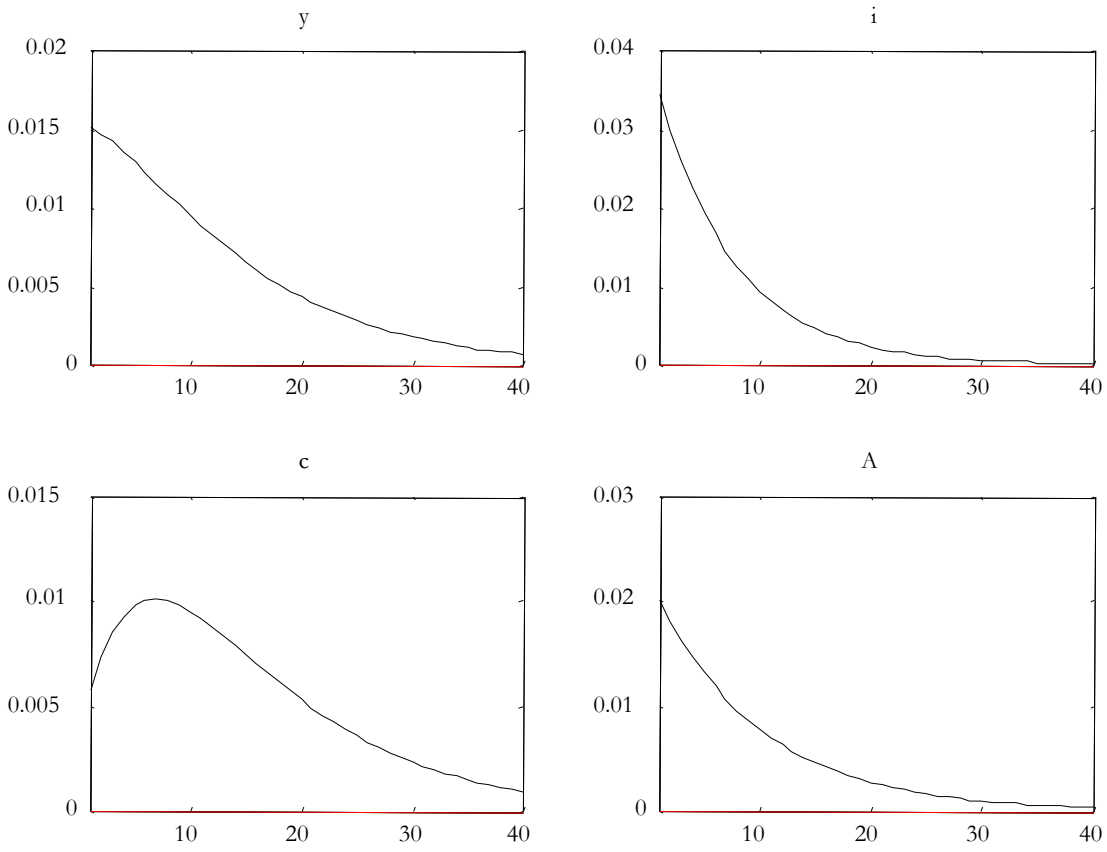
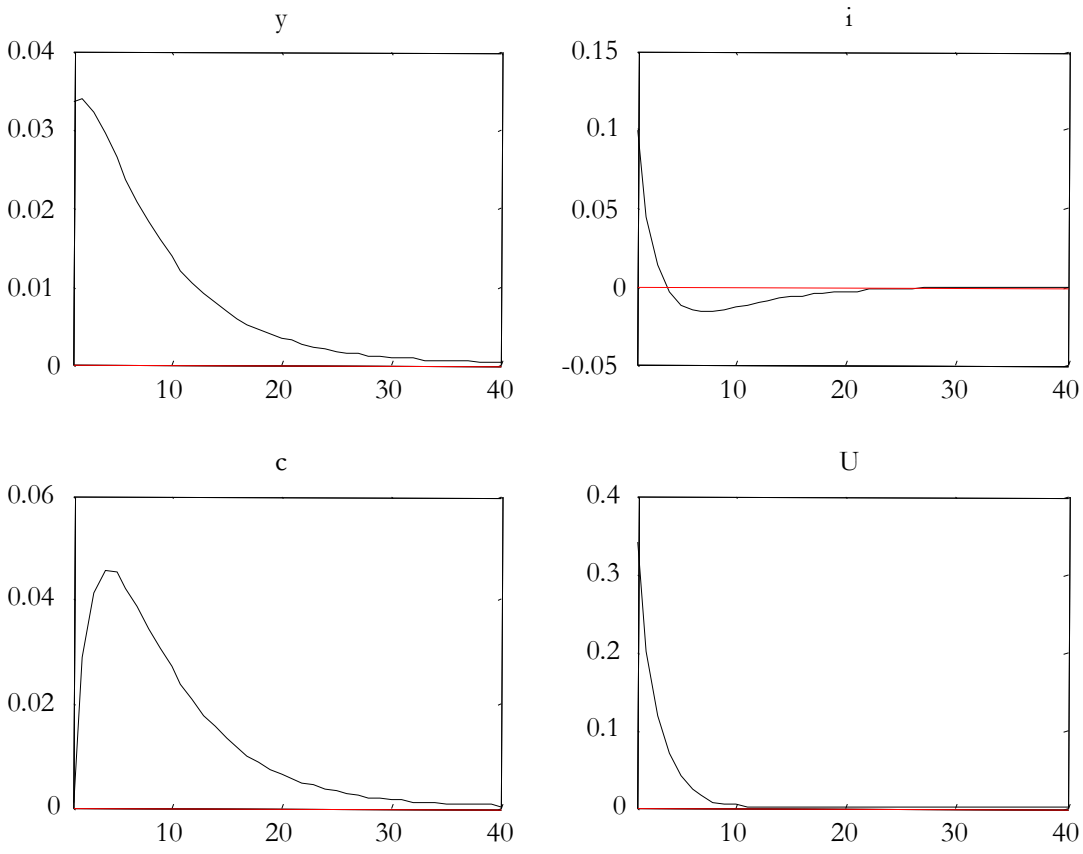

y
0.02
0.015
0.01
0.005
0
10
20
30
40
i
0.04
0.03
0.02
0.01
0
10
20
30
40
c
0.015
0.01
0.005
0
10
20
30
40
A
0.03
0.02
0.01
0
10
20
30
40

**Figure 8 (ii)**


y
0.04
0.03
0.02
0.01
0
10
20
30
40
i
0.15
0.1
0.05
0
-0.05
10
20
30
40
c
0.06
0.04
0.02
0
10
20
30
40
U
0.4
0.3
0.2
0.1
0
10
20
30
40

## Table 1

### Average GDP Share

| Decade | Agriculture | Non-Agricultural |
|---|---|---|
| **1950's** | 48.0 | 52.0 |
| **1960's** | 40.4 | 59.6 |
| **1970's** | 33.7 | 66.3 |
| **1980's** | 27.6 | 72.4 |
| **1990's** | 25.4 | 74.6 |
| **2000's** | 22.6 | 77.8 |

### Average Share of Agriculture Sector

| Decade | GDP Share | Employment Share |
|---|---|---|
| **1950's** | 48.0 | |
| **1960's** | 40.4 | 56.3 |
| **1970's** | 33.7 | 56.2 |
| **1980's** | 27.6 | 51.5 |
| **1990's** | 25.4 | 47.5 |
| **2000's** | 22.6 | 43.8 |

### Average Employment Share

| Decade | Agriculture | Non-Agricultural |
|---|---|---|
| **1960's** | 56.3 | 43.7 |
| **1970's** | 56.2 | 43.8 |
| **1980's** | 51.5 | 48.5 |
| **1990's** | 47.5 | 52.8 |
| **2000's** | 43.8 | 56.2 |

## Table 2

### LONG RUN RATIOS

**1960-2010**

| | PC/Y | GC/Y | GDFCF/Y | FDI/Y | EXP/Y | IMP/Y |
|---|---|---|---|---|---|---|
| **Min** | 0.68 | 0.08 | 0.11 | 0.00 | 0.06 | 0.09 |
| **Max** | 0.84 | 0.17 | 0.21 | 0.04 | 0.17 | 0.24 |
| **Average** | 0.77 | 0.11 | 0.16 | 0.01 | 0.12 | 0.18 |
| **Std.dev** | 0.04 | 0.02 | 0.02 | 0.01 | 0.04 | 0.04 |
| **Median** | 0.76 | 0.11 | 0.17 | 0.01 | 0.13 | 0.18 |
| **Std.dev/Average** | 5.2% | 17.9% | 14.4% | 119.5% | 28.9% | 21.8% |
| **Std.dev/Median** | 5.2% | 18.3% | 14.2% | 156.0% | 27.4% | 21.0% |

**1960-1980**

| | PC/Y | GC/Y | GDFCF/Y | FDI/Y | EXP/Y | IMP/Y |
|---|---|---|---|---|---|---|
| **Min** | 0.72 | 0.10 | 0.11 | 0.00 | 0.06 | 0.09 |
| **Max** | 0.84 | 0.15 | 0.21 | 0.01 | 0.15 | 0.23 |
| **Average** | 0.79 | 0.11 | 0.15 | 0.00 | 0.09 | 0.15 |
| **Std.dev** | 0.03 | 0.01 | 0.03 | 0.00 | 0.03 | 0.04 |
| **Median** | 0.79 | 0.11 | 0.15 | 0.00 | 0.08 | 0.14 |
| **Std.dev/Average** | 4.1% | 9.7% | 18.3% | 132.6% | 28.2% | 26.2% |
| **Std.dev/Median** | 4.1% | 9.9% | 18.5% | 267.2% | 32.5% | 27.6% |

# Table 2

## LONG RUN RATIOS

**1981-2010**

| | PC/Y | GC/Y | GDFCF/Y | FDI/Y | EXP/Y | IMP/Y |
|---|---|---|---|---|---|---|
| **Min** | 0.68 | 0.08 | 0.14 | 0.00 | 0.10 | 0.15 |
| **Max** | 0.83 | 0.17 | 0.21 | 0.04 | 0.17 | 0.24 |
| **Average** | 0.75 | 0.11 | 0.17 | 0.01 | 0.14 | 0.20 |
| **Std.dev** | 0.04 | 0.02 | 0.02 | 0.01 | 0.02 | 0.03 |
| **Median** | 0.75 | 0.12 | 0.17 | 0.01 | 0.15 | 0.20 |
| **Std.dev/Average** | 5.1% | 21.6% | 10.2% | 92.3% | 13.5% | 13.0% |
| **Std.dev/Median** | 5.1% | 21.1% | 10.2% | 133.9% | 13.3% | 12.7% |

**% Change between (1960-1980) and (1981-2010)**

| | PC/Y | GC/Y | GDFCF/Y | FDI/Y | EXP/Y | IMP/Y |
|---|---|---|---|---|---|---|
| **Min** | -4.9% | -19.7% | 30.7% | -275.9% | 63.9% | 69.2% |
| **Max** | -1.6% | 14.4% | -2.6% | 231.9% | 17.0% | 2.5% |
| **Average** | -4.6% | 4.1% | 10.1% | 309.9% | 62.6% | 29.4% |
| **Std.dev** | 18.4% | 133.4% | -38.3% | 185.3% | -21.9% | -35.7% |
| **Median** | -5.2% | 9.8% | 11.8% | 469.5% | 90.7% | 40.2% |
| **Std.dev/Average** | 24.0% | 124.1% | -44.0% | -30.4% | -52.0% | -50.3% |
| **Std.dev/Median** | 24.9% | 112.5% | -44.8% | -49.9% | -59.0% | -54.2% |

# Table 3A

## GROWTH RATE

### 1982-2010

| | Output | Investment | Private Investment | All Public Investment | Public Investment | Government Investment | Priavte Domestic Investment | Foreign Direct Investment |
|---|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | | |
| **Investment** | 0.54*** | 1.00 | | | | | | |
| **Private Investment** | 0.27 | 0.85*** | 1.00 | | | | | |
| **All Public Investment** | 0.58*** | 0.61*** | 0.12 | 1.00 | | | | |
| **Public Investment** | 0.36* | 0.52*** | 0.09 | 0.88*** | 1.00 | | | |
| **Government Investment** | 0.64*** | 0.45** | 0.15 | 0.58*** | 0.16 | 1.00 | | |
| **Priavte Domestic Investment** | 0.10 | 0.68*** | 0.92*** | -0.07 | -0.01 | -0.09 | 1.00 | |
| **Foreign Direct Investment** | 0.36* | 0.43** | 0.30 | 0.31 | 0.16 | 0.47*** | -0.01 | 1.00 |

### 1982-1990

| | Output | Investment | Private Investment | All Public Investment | Public Investment | Government Investment | Priavte Domestic Investment | Foreign Direct Investment |
|---|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | | |
| **Investment** | -0.10 | 1.00 | | | | | | |
| **Private Investment** | -0.41 | 0.37 | 1.00 | | | | | |
| **All Public Investment** | 0.20 | 0.79** | -0.27 | 1.00 | | | | |
| **Public Investment** | 0.06 | 0.91*** | 0.13 | 0.87*** | 1.00 | | | |
| **Government Investment** | 0.27 | -0.10 | -0.81*** | 0.40 | -0.10 | 1.00 | | |
| **Priavte Domestic Investment** | -0.33 | 0.36 | 0.94*** | -0.24 | 0.19 | -0.85*** | 1.00 | |
| **Foreign Direct Investment** | 0.07 | -0.11 | -0.58* | 0.25 | -0.12 | 0.74** | -0.81*** | 1.00 |

## Table 3A

### GROWTH RATE

**1991-2000**

| | Output | Investment | Private Investment | All Public Investment | Public Investment | Government Investment | Priavte Domestic Investment | Foreign Direct Investment |
|---|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | | |
| **Investment** | 0.46 | 1.00 | | | | | | |
| **Private Investment** | 0.03 | 0.76** | 1.00 | | | | | |
| **All Public Investment** | 0.61* | 0.42 | -0.27 | 1.00 | | | | |
| **Public Investment** | 0.46 | 0.40 | -0.24 | 0.94*** | 1.00 | | | |
| **Government Investment** | 0.60* | 0.18 | -0.21 | 0.52 | 0.20 | 1.00 | | |
| **Priavte Domestic Investment** | -0.17 | 0.58* | 0.92*** | -0.42 | -0.34 | -0.40 | 1.00 | |
| **Foreign Direct Investment** | 0.41 | 0.31 | 0.12 | 0.30 | 0.22 | 0.30 | -0.25 | 1.00 |

**2001-2010**

| | Output | Investment | Private Investment | All Public Investment | Public Investment | Government Investment | Priavte Domestic Investment | Foreign Direct Investment |
|---|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | | |
| **Investment** | 0.70** | 1.00 | | | | | | |
| **Private Investment** | 0.60* | 0.94*** | 1.00 | | | | | |
| **All Public Investment** | 0.61* | 0.70** | 0.41 | 1.00 | | | | |
| **Public Investment** | 0.37 | 0.57* | 0.30 | 0.88*** | 1.00 | | | |
| **Government Investment** | 0.77*** | 0.69** | 0.57* | 0.69** | 0.31 | 1.00 | | |
| **Priavte Domestic Investment** | 0.58* | 0.86*** | 0.96*** | 0.28 | 0.25 | 0.39 | 1.00 | |
| **Foreign Direct Investment** | 0.49 | 0.82*** | 0.87*** | 0.39 | 0.25 | 0.63* | 0.73** | 1.00 |

## Table 3B

### GROWTH RATE

**1982-2010**

| | Output | Investment | Foreign Direct Investment | Private Consumption | Government Consumptions | Exports | Imports |
|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | |
| **Investment** | 0.54*** | 1.00 | | | | | |
| **Foreign Direct Investment** | 0.36* | 0.43** | 1.00 | | | | |
| **Private Consumption** | 0.54** | 0.08 | 0.08 | 1.00 | | | |
| **Government Consumptions** | 0.34* | 0.47** | 0.38** | -0.12 | 1.00 | | |
| **Exports** | 0.32* | 0.10 | -0.15 | -0.19 | 0.13 | 1.00 | |
| **Imports** | 0.47*** | 0.60*** | 0.28 | 0.50*** | 0.55*** | 0.16 | 1.00 |

**1982-1990**

| | Output | Investment | Foreign Direct Investment | Private Consumption | Government Consumptions | Exports | Imports |
|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | |
| **Investment** | -0.10 | 1.00 | | | | | |
| **Foreign Direct Investment** | 0.07 | -0.11 | 1.00 | | | | |
| **Private Consumption** | 0.46 | -0.52 | 0.08 | 1.00 | | | |
| **Government Consumptions** | 0.56 | -0.01 | -0.14 | -0.13 | 1.00 | | |
| **Exports** | -0.06 | 0.44 | -0.63* | -0.63* | 0.22 | 1.00 | |
| **Imports** | 0.41 | -0.04 | -0.51 | 0.61* | 0.29 | 0.04 | 1.00 |

## Table 3B

### GROWTH RATE

**1991-2000**

| | Output | Investment | Foreign Direct Investment | Private Consumption | Government Consumptions | Exports | Imports |
|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | |
| **Investment** | 0.46 | 1.00 | | | | | |
| **Foreign Direct Investment** | 0.41 | 0.31 | 1.00 | | | | |
| **Private Consumption** | 0.67** | 0.27 | 0.25 | 1.00 | | | |
| **Government Consumptions** | 0.42 | -0.05 | 0.71** | 0.39 | 1.00 | | |
| **Exports** | 0.68** | 0.07 | 0.38 | 0.15 | 0.52 | 1.00 | |
| **Imports** | 0.52 | 0.41 | 0.53 | 0.80*** | 0.67** | 0.27 | 1.00 |

**2001-2010**

| | Output | Investment | Foreign Direct Investment | Private Consumption | Government Consumptions | Exports | Imports |
|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | |
| **Investment** | 0.70** | 1.00 | | | | | |
| **Foreign Direct Investment** | 0.49 | 0.82*** | 1.00 | | | | |
| **Private Consumption** | 0.57* | 0.10 | -0.11 | 1.00 | | | |
| **Government Consumptions** | 0.27 | 0.62* | 0.55 | -0.39 | 1.00 | | |
| **Exports** | 0.14 | 0.01 | 0.03 | -0.04 | -0.14 | 1.00 | |
| **Imports** | 0.44 | 0.80*** | 0.55* | 0.15 | 0.60* | 0.16 | 1.00 |

## Table 4A

### HP FILTER DATA

**1981-2010**

| | Output | Investment | Private Investment | All Public Investment | Public Investment | Government Investment | Priavte Domestic Investment | Foreign Direct Investment |
|---|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | | |
| **Investment** | 0.72*** | 1.00 | | | | | | |
| **Private Investment** | 0.53*** | 0.92*** | 1.00 | | | | | |
| **All Public Investment** | 0.71*** | 0.76*** | 0.45** | 1.00 | | | | |
| **Public Investment** | 0.41** | 0.52*** | 0.23 | 0.86*** | 1.00 | | | |
| **Government Investment** | 0.81*** | 0.76*** | 0.59*** | 0.73*** | 0.29 | 1.00 | | |
| **Priavte Domestic Investment** | 0.30 | 0.76*** | 0.93*** | 0.23 | 0.08 | 0.37** | 1.00 | |
| **Foreign Direct Investment** | 0.71*** | 0.68*** | 0.58*** | 0.55*** | 0.25 | 0.73*** | 0.28 | 1.00 |

**1981-1990**

| | Output | Investment | Private Investment | All Public Investment | Public Investment | Government Investment | Priavte Domestic Investment | Foreign Direct Investment |
|---|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | | |
| **Investment** | -0.06 | 1.00 | | | | | | |
| **Private Investment** | -0.58* | 0.30 | 1.00 | | | | | |
| **All Public Investment** | 0.43 | 0.68** | -0.49 | 1.00 | | | | |
| **Public Investment** | 0.27 | 0.79*** | -0.18 | 0.88*** | 1.00 | | | |
| **Government Investment** | 0.44 | 0.15 | -0.72** | 0.67** | 0.23 | 1.00 | | |
| **Priavte Domestic Investment** | -0.55 | 0.23 | 0.95*** | 0.51 | -0.15 | -0.82*** | 1.00 | |
| **Foreign Direct Investment** | 0.07 | 0.15 | -0.20 | 0.26 | -0.03 | 0.60* | -0.49 | 1.00 |

## Table 4A

### HP FILTER DATA

**1991-2000**

| | Output | Investment | Private Investment | All Public Investment | Public Investment | Government Investment | Priavte Domestic Investment | Foreign Direct Investment |
|---|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | | |
| **Investment** | 0.53 | 1.00 | | | | | | |
| **Private Investment** | 0.05 | 0.72** | 1.00 | | | | | |
| **All Public Investment** | 0.70** | 0.69** | 0.00 | 1.00 | | | | |
| **Public Investment** | 0.61* | 0.69** | 0.04 | 0.97*** | 1.00 | | | |
| **Government Investment** | 0.66** | 0.39 | -0.14 | 0.69** | 0.48 | 1.00 | | |
| **Priavte Domestic Investment** | -0.28 | 0.48 | 0.89*** | -0.23 | -0.16 | -0.37 | 1.00 | |
| **Foreign Direct Investment** | 0.73** | 0.37 | 0.09 | 0.44 | 0.37 | 0.47 | -0.37 | 1.00 |

**2001-2010**

| | Output | Investment | Private Investment | All Public Investment | Public Investment | Government Investment | Priavte Domestic Investment | Foreign Direct Investment |
|---|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | | |
| **Investment** | 0.87*** | 1.00 | | | | | | |
| **Private Investment** | 0.84*** | 0.97*** | 1.00 | | | | | |
| **All Public investment** | 0.52 | 0.73** | 0.61* | 1.00 | | | | |
| **Public Investment** | 0.46 | 0.60* | 0.40 | 0.89*** | 1.00 | | | |
| **Government Investment** | 0.34 | 0.54 | 0.62* | 0.64** | 0.22 | 1.00 | | |
| **Priavte Domestic Investment** | 0.86*** | 0.92*** | 0.98*** | 0.52 | 0.32 | 0.59* | 1.00 | |
| **Foreign Direct Investment** | 0.73** | 0.92*** | 0.96*** | 0.57* | 0.33 | 0.66** | 0.89*** | 1.00 |

## Table 4B

### HP FILTER DATA

**1981-2010**

| | Output | Investment | Foreign Direct Investment | Private Consumption | Government Consumptions | Exports | Imports |
|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | |
| **Investment** | 0.72*** | 1.00 | | | | | |
| **Foreign Direct Investment** | 0.71*** | 0.68*** | 1.00 | | | | |
| **Private Consumption** | 0.60*** | 0.23 | 0.31* | 1.00 | | | |
| **Government Consumptions** | 0.61*** | 0.58*** | 0.66*** | 0.12 | 1.00 | | |
| **Exports** | 0.43** | 0.29 | 0.21 | -0.11 | 0.24 | 1.00 | |
| **Imports** | 0.76*** | 0.78*** | 0.66*** | 0.60*** | 0.67*** | 0.30 | 1.00 |

**1981-1990**

| | Output | Investment | Foreign Direct Investment | Private Consumption | Government Consumptions | Exports | Imports |
|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | |
| **Investment** | -0.06 | 1.00 | | | | | |
| **Foreign Direct Investment** | 0.07 | 0.15 | 1.00 | | | | |
| **Private Consumption** | 0.15 | -0.68** | -0.11 | 1.00 | | | |
| **Government Consumptions** | 0.66** | -0.03 | -0.18 | -0.19 | 1.00 | | |
| **Exports** | 0.00 | 0.56* | -0.35 | -0.78*** | 0.26 | 1.00 | |
| **Imports** | 0.01 | -0.40 | -0.52 | 0.68** | 0.11 | -0.27 | 1.00 |

## Table 4B

### HP FILTER DATA

**1991-2000**

| | Output | Investment | Foreign Direct Investment | Private Consumption | Government Consumptions | Exports | Imports |
|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | |
| **Investment** | 0.53 | 1.00 | | | | | |
| **Foreign Direct Investment** | 0.73** | 0.37 | 1.00 | | | | |
| **Private Consumption** | 0.85*** | 0.56* | 0.60* | 1.00 | | | |
| **Government Consumptions** | 0.58* | 0.02 | 0.86*** | 0.53 | 1.00 | | |
| **Exports** | 0.78*** | 0.08 | 0.80*** | 0.60* | 0.84*** | 1.00 | |
| **Imports** | 0.67** | 0.53 | 0.76** | 0.83*** | 0.75** | 0.66** | 1.00 |

**2001-2010**

| | Output | Investment | Foreign Direct Investment | Private Consumption | Government Consumptions | Exports | Imports |
|---|---|---|---|---|---|---|---|
| **Output** | 1.00 | | | | | | |
| **Investment** | 0.87*** | 1.00 | | | | | |
| **Foreign Direct Investment** | 0.73** | 0.92*** | 1.00 | | | | |
| **Private Consumption** | 0.54 | 0.28 | -0.01 | 1.00 | | | |
| **Government Consumptions** | 0.50 | 0.76** | 0.74** | -0.22 | 1.00 | | |
| **Exports** | 0.41 | 0.16 | 0.28 | 0.06 | 0.02 | 1.00 | |
| **Imports** | 0.79*** | 0.92*** | 0.78*** | 0.40 | 0.73** | 0.17 | 1.00 |

## Table 5

### Relevant Moments of GR of Macroeconomic Variables (IFS)

| Volatility of Macro Variables | | | | |
|---|---|---|---|---|
| | **1982-2010** | **1982-1990** | **1991-2000** | **2001-2010** |
| Real Output | 0.0218 | 0.0105 | 0.0274 | 0.0232 |
| Real Investment | 0.0878 | 0.0301 | 0.0795 | 0.1289 |
| Real FDI | 0.5445 | 0.6685 | 0.5128 | 0.4784 |
| Real Private Consumption | 0.0343 | 0.0320 | 0.0417 | 0.0282 |
| Real Government Consumption | 0.1486 | 0.0738 | 0.0753 | 0.2269 |
| Real Exports | 0.0942 | 0.1275 | 0.0896 | 0.0663 |
| Real Imports | 0.1155 | 0.0608 | 0.1196 | 0.1461 |

| Relative Volatility of Macro Variables | | | | |
|---|---|---|---|---|
| | **1982-2010** | **1982-1990** | **1991-2000** | **2001-2010** |
| Real Output | 1.00 | 1.00 | 1.00 | 1.00 |
| Real Investment | 4.04 | 2.86 | 2.90 | 5.56 |
| Real FDI | 25.01 | 63.43 | 18.70 | 20.64 |
| Real Private Consumption | 1.57 | 3.03 | 1.52 | 1.22 |
| Real Government Consumption | 6.83 | 7.01 | 2.75 | 9.79 |
| Real Exports | 4.33 | 12.10 | 3.27 | 2.86 |
| Real Imports | 5.31 | 5.77 | 4.36 | 6.30 |

## Table 5

### Relevant Moments of GR of Macroeconomic Variables (IFS)

| Contemparaneous Correlation of Macro Variables with Output | | | | |
|---|---|---|---|---|
| | **1982-2010** | **1982-1990** | **1991-2000** | **2001-2010** |
| Real Output | 1.00 | 1.00 | 1.00 | 1.00 |
| Real Investment | 0.54*** | -0.10 | 0.46 | 0.70** |
| Real FDI | 0.36* | 0.07 | 0.41 | 0.49 |
| Real Private Consumption | 0.54** | 0.46 | 0.67** | 0.57* |
| Real Government Consumption | 0.34* | 0.56 | 0.42 | 0.27 |
| Real Exports | 0.32* | -0.06 | 0.68** | 0.14 |
| Real Imports | 0.47*** | 0.41 | 0.52 | 0.44 |

| Autocorrelation of Macro Variables | | | | |
|---|---|---|---|---|
| | **1982-2010** | **1982-1990** | **1991-2000** | **2001-2010** |
| Real Output | 0.23 | -0.29 | 0.01 | 0.47 |
| Real Investment | 0.42 | -0.55 | 0.08 | 0.62 |
| Real FDI | -0.09 | -0.49 | -0.19 | 0.39 |
| Real Private Consumption | -0.13 | -0.20 | -0.41 | 0.10 |
| Real Government Consumption | -0.24 | -0.06 | 0.15 | -0.52 |
| Real Exports | -0.09 | -0.50 | 0.26 | 0.24 |
| Real Imports | -0.02 | -0.28 | -0.05 | -0.03 |

## Table 6

### Relevant Moments of HP Filtered Macroeconomic Variables (IFS)

| Volatility of Macro Variables | | | | |
|---|---|---|---|---|
| | **1981-2010** | **1981-1990** | **1991-2000** | **2001-2010** |
| Real Output | 0.0219 | 0.0070 | 0.0222 | 0.0233 |
| Real Investment | 0.0983 | 0.0185 | 0.0635 | 0.1475 |
| Real FDI | 0.3849 | 0.3091 | 0.3151 | 0.4353 |
| Real Private Consumption | 0.0287 | 0.0242 | 0.0291 | 0.0208 |
| Real Government Consumption | 0.1203 | 0.0509 | 0.0715 | 0.1560 |
| Real Exports | 0.0776 | 0.0835 | 0.0617 | 0.0621 |
| Real Imports | 0.1110 | 0.0431 | 0.1019 | 0.1329 |

| Relative Volatility of Macro Variables | | | | |
|---|---|---|---|---|
| | **1981-2010** | **1981-1990** | **1991-2000** | **2001-2010** |
| Real Output | 1.00 | 1.00 | 1.00 | 1.00 |
| Real Investment | 4.50 | 2.63 | 2.85 | 6.32 |
| Real FDI | 17.61 | 44.05 | 14.17 | 18.66 |
| Real Private Consumption | 1.31 | 3.44 | 1.31 | 0.89 |
| Real Government Consumption | 5.50 | 7.26 | 3.22 | 6.69 |
| Real Exports | 3.55 | 11.90 | 2.78 | 2.66 |
| Real Imports | 5.08 | 6.14 | 4.58 | 5.69 |

# Table 6

## Relevant Moments of HP Filtered Macroeconomic Variables (IFS)

| Contemparaneous Correlation of Macro Variables with Output | | | | |
|---|---|---|---|---|
| | **1981-2010** | **1981-1990** | **1991-2000** | **2001-2010** |
| Real Output | 1.00 | 1.00 | 1.00 | 1.00 |
| Real Investment | 0.72*** | -0.06 | 0.53 | 0.87*** |
| Real FDI | 0.71*** | 0.07 | 0.73** | 0.73** |
| Real Private Consumption | 0.60*** | 0.15 | 0.85*** | 0.54 |
| Real Government Consumption | 0.61*** | 0.66** | 0.58* | 0.50 |
| Real Exports | 0.43** | 0.00 | 0.78*** | 0.41 |
| Real Imports | 0.76*** | 0.01 | 0.67** | 0.79*** |

| Autocorrelation of Macro Variables | | | | |
|---|---|---|---|---|
| | **1981-2010** | **1981-1990** | **1991-2000** | **2001-2010** |
| Real Output | 0.58 | -0.23 | 0.23 | 0.59 |
| Real Investment | 0.62 | -0.22 | 0.09 | 0.61 |
| Real FDI | 0.40 | -0.26 | 0.25 | 0.55 |
| Real Private Consumption | 0.37 | 0.17 | 0.00 | 0.10 |
| Real Government Consumption | 0.33 | -0.13 | 0.37 | -0.09 |
| Real Exports | 0.30 | -0.24 | 0.20 | 0.48 |
| Real Imports | 0.51 | 0.11 | 0.21 | 0.36 |

## Table 7

### Comparison of Relevant Moments of HP Filtered Macroeconomic Variables

| Volatility of Macro Variables | | | | |
|---|---|---|---|---|
| | **1981-2010** | **2001-2010** | **RBC Model** | **Augmented RBC Model** |
| Real Output | 0.0219 | 0.0233 | 0.0142 | 0.0305 |
| Real Investment | 0.0983 | 0.1475 | 0.0324 | 0.0853 |
| Real Private Consumption | 0.0287 | 0.0208 | 0.0063 | 0.0317 |
| Real FDI | 0.3849 | 0.4353 | | 0.3161 |

| Relative Volatility of Macro Variables | | | | |
|---|---|---|---|---|
| | **1981-2010** | **2001-2010** | **RBC Model** | **Augmented RBC Model** |
| Real Output | 1.00 | 1.00 | 1.00 | 1.00 |
| Real Investment | 4.50 | 6.32 | 2.28 | 2.80 |
| Real Private Consumption | 1.31 | 0.89 | 0.44 | 1.04 |
| Real FDI | 17.61 | 18.66 | | 10.36 |

| Contemparaneous Correlation of Macro Variables with Output | | | | |
|---|---|---|---|---|
| | **1981-2010** | **2001-2010** | **RBC Model** | **Augmented RBC Model** |
| Real Output | 1.00 | 1.00 | 1.00 | 1.00 |
| Real Investment | 0.72*** | 0.87*** | 0.98 | 0.74 |
| Real Private Consumption | 0.60*** | 0.54 | 0.88 | 0.47 |
| Real FDI | 0.71*** | 0.73** | | 0.73 |

| Autocorrelation of Macro Variables | | | | |
|---|---|---|---|---|
| | **1981-2010** | **2001-2010** | **RBC Model** | **Augmented RBC Model** |
| Real Output | 0.58 | 0.59 | 0.50 | 0.54 |
| Real Investment | 0.62 | 0.61 | 0.45 | 0.31 |
| Real Private Consumption | 0.37 | 0.10 | 0.69 | 0.76 |
| Real FDI | 0.40 | 0.55 | | 0.30 |