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Contents

Effects of International Trade, FDI and Environmental Regulation on Sustainable Development: China Data

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Abstract

In this paper, we examine the effects of international trade, foreign direct investment and environmental regulation on sustainable development under a macro-econometric model framework. Both single and mixed variations in exogenous variables are taken into consideration in the simulation scenarios. The larger inflow of FDI (foreign direct investment) and the depreciation of the Yuan exchange rate have a positive effect on the Chinese economy, but a negative effect on carbon emission control. However, the simulation of environmental regulations shows that carbon and energy taxes lead to a drop in both economic growth and carbon emissions. In simulation scenarios, such disparate effects of international trade and environmental regulations result in an economy that shrinks in the short run but grows in the long run as carbon emissions are reduced. We also forecast economic growth, energy demand and carbon emissions for the period 2000-2020. To maintain a sustainable developmental path for a growing economy, neither economic nor environmental policies can be ignored.

KEYWORDS: *Trade, FDI, Environmental policy, Sustainable development*

1. Introduction

As a result of the recent trend towards globalization, the relationship between international trade and sustainable development has been widely debated. There is a "pollution haven" hypothesis which claims that free international trade and capital flows will induce the migration of polluting industries using low technology to developing countries with less stringent environmental regulations. Many analysts provide strong theoretical arguments for the validity of that hypothesis, and some empirical studies have also found that environmental factors have a significant impact on trade and industrial transformation (Kalt (1988), Low and Yeats (1992), Han and Braden (1996), Xing and Kolstad (1996), Mani and Wheeler (1997)). However, some studies could find no significant empirical evidence for the "pollution haven" hypothesis (Kalt (1988), Grossman and Krueger (1992), Tobey (1993), Bouman (1996), Kodama (2000), Sorsa (1994) and Repetto (1995)). Birdsall and Wheeler (1992) and Lucas et al. (1992) suggest that FDI flows into industries have a positive impact: the more open an economy is, the more possible it is to attract cleaner industries. Letachumanan and Kodama (2000) estimated an emerging trajectory of international technology transfer favoring high-technology industries. These results are highly dependent on the specifications of the methods used.

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Since the reforms and the "open-door" policy that it established in 1978, China has experienced impressive economic growth in which international trade and foreign direct investment play a positive role. In the future, China will continue to strive to maintain a stable and consistent policy of absorbing FDI and of further improving the environment for attracting it. Sustainable development has also been taken as a basic strategy for economic growth and social progress since the World Environment and Development Congress in 1992. In this paper, we try to examine the sustainable development of the Chinese economy under the effects of international trade, foreign direct investment and environmental regulation using a macro-econometric model framework. The paper is arranged as follows: the structure of the macro- and environmental econometric model is described in the next section. The third section is devoted to the data and the estimated results of the structure equations. The fourth section presents and discusses the simulated results of several scenarios. The last section offers concluding remarks based on the study.

2. Structure of the Model

To analyze the effects of international trade, FDI and environmental regulation on sustainable development in China, a macro- and environmental econometric model (see figure 1) has been set up based on the Chinese macro-econometric models developed by Kinoshita and Wu (2001). It consists of six blocks: aggregate demand, output and income, price, employment, energy demand and environment. GDP in this model is determined by the supply side, the sum of sector outputs, which are related to both demand factors and production factors, such as employment and imports. The gap with expenditure GDP is absorbed by the statistical discrepancy. The main features of each block are described in order below.

2.1 Aggregate Demand Block

In this block, 9 endogenous variables are determined. Private consumption (CP) is a function of gross national income adjusted for inflation (GNPV/PCP) with a time lag, while fixed investment (FI) is determined solely by financial availability (CREDIT) and foreign direct investment received (FDIR). Inventory investment (J) is a nonlinear function of GDP and existing inventory stock. Exports (XGS) and imports (MGS) are related to income or demand, relative price and foreign direct investment. As a result, the foreign direct investment received will affect aggregate expenditures through three channels: domestic fixed investment, exports and imports.

Aggregate Demand-Supply Balance

GDP=CP+CGV*100/PCG+FI+J+XGS-MGS+EPSV*100/PGDP

Real Private Consumption

CP=F(GNPV/PCP, CP(-1))

Nominal Public Consumption

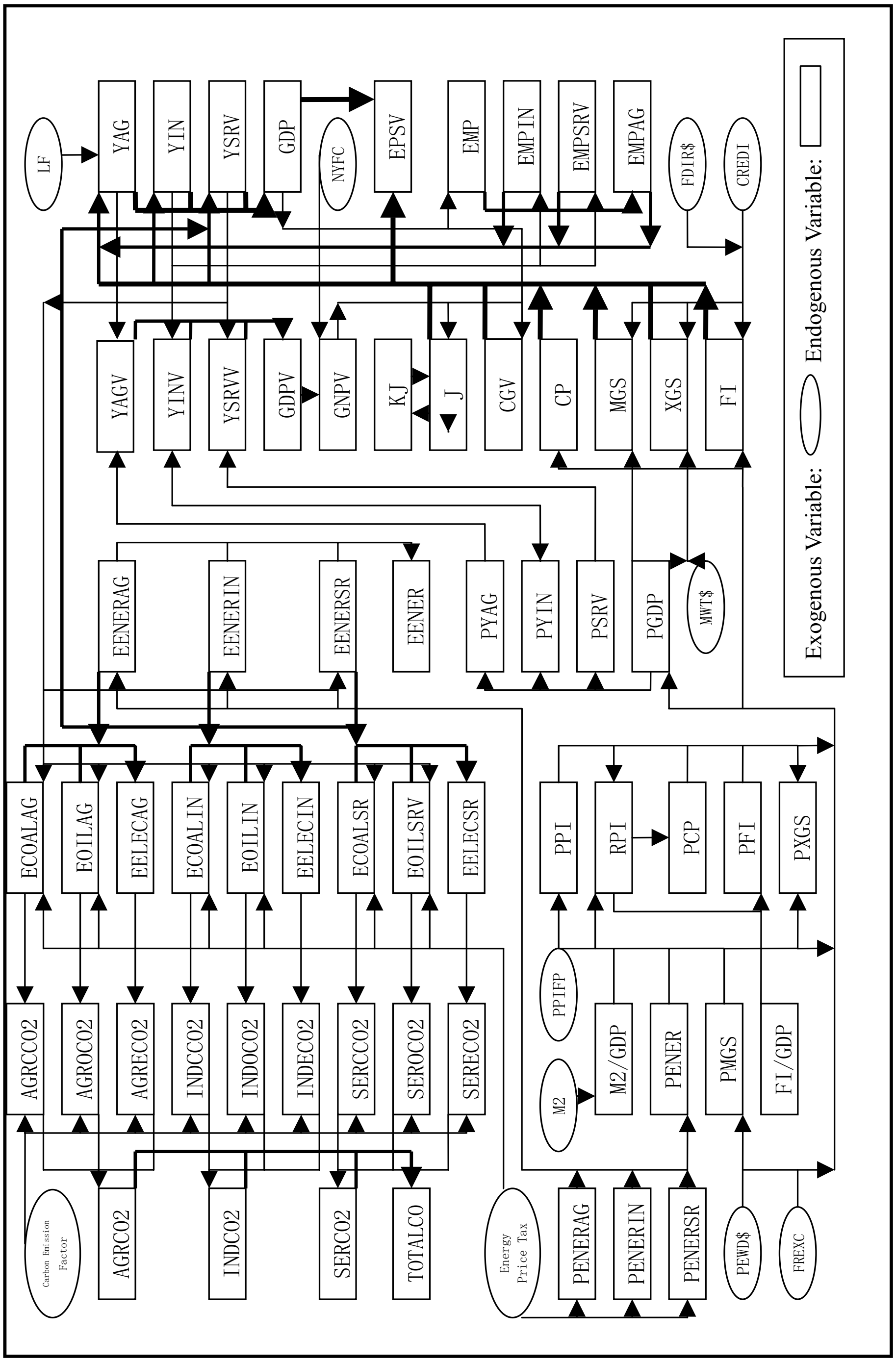
CGV=F(GNPV-GNPV(-1), GNPV(-1))

Real Fixed Investment

FI=F(CREDIT/PFI, FDIR/PFI)

Real Inventory Investment

Figure 1 Framework of the Macro and Environment Model



J=F(GDP, GDP*GDP, KJ(-1))

Real Exports

XGS=F(MWT$,PXGS/FREXCH/PEWD$,FDIR/PFI+FDIR(-1)/PFI(-1), XGS(-1))

Real Imports

MGS=F(GDP, PMGS/PGDP, FDIR/PGDP)

Inventory Stock

KJ=KJ(-1)+J

Statistical Discrepancy

EPSV=GDPV-(CP*PCP+CGV+FI*PFI+JV+XGS*PXGS/100-MGS*PMGS/100)

2.2 Output and Income Block

In this block, the production sector is disaggregated into agricultural (AG), industrial (IN) and tertiary (SRV) sectors, and the real output (value-added) of each sector is determined by supply and demand factors. Nominal outputs of the three sectors are the product of real output and output deflators by sector. GDP, GDPV and GNPV are given by the sum of relevant components as an identity.

Real Output of Primary Industry

YAG=F(LF, CP, EENERAG)

Real Output of Secondary Industry

YIN=F(FI, XGS, YIN(-1), EENERIN)

Real Output of Tertiary Industry

YSRV=F(YAG, YIN, YSRV(-1), EENERSRV)

Real GDP

GDP=YAG+YIN+YSRV

Nominal Output of Agricultural Sector

YAGV=YAG*PYAG/100

Nominal Output of Industrial Sector

YINV=YIN*PYIN/100

Nominal Output of Tertiary Sector

YSRVV=YSRV*PYSRV/100

Nominal GDP

GDPV=YAGV+YINV+YSRVV

Nominal GNP

GNPV=GDPV+NYFC

2.3 Price Block

The price block includes seven price indices and 8 aggregate-demand and sector-output deflators. The aggregate energy price (PENER) is a function of those prices in three industry sectors (PENERAG, PENERIN, PENERSER), which is determined by different kinds of energy price (PCOAL, PELE, POIL). The producer price index (PPI) is determined by the import price (PMGS), PENER and purchasing price index of food products (PPIFP) as a proxy of labor cost, while the retail price index (RPI) is explained by the price of agricultural and non-agricultural products and the money supply factor (M2). The consumer price index (CPI) is simply a function of the retail price index. Consumption and investment deflators are related to CPI and the producer price index, respectively, and determine the GDP deflator, which in turn determines the sector-output deflators.

Aggregate Energy Price by Sectors

PENER(i)=F(PCOAL(i), PELE(i), POIL(i)), i=AG, IN, SER

Aggregate Energy Price

PENER=F(PENERAG, PENERIN, PENERSER)

Producer Price Index

PPI=F(PMGS, PPIFP, M2/GDP, PENER)

Retail Price Index

RPI=F(PPIFP, PPI, M2/GDP)

Private-Consumption Deflator

PCP=F(CPI, PCP(-1))

Fixed-Investment Deflator

PFI=F(PPI, FREXCH)

Export Deflator

PXGS=F(PPI, PMGS, FREXCH)

Import Deflator

PMGS=F(PEWD$, FREXCH)

Output Deflator of Primary Industry

PYAG=F(PGDP)

Output Deflator of Secondary Industry

PYIN=F(PGDP)

Output Deflator of Tertiary Industry

PYSRV=F(PGDP)

GDP Deflator

PGDP=F(PCP, PFI)

2.4 Employment Block

Employment by sector is dependent on demand/supply factors in each sector, while total employment (EMP) is constrained by the size of the working-age population (LF). As a result, one of the three sectors is assumed to absorb the labor force not employed in the remaining two sectors. Here, agricultural employment (EMPAG) is determined as the residual of employment.

Total Employment

EMP=F(LF, GDP(-1)/EMP(-1))

Employment in Secondary Industry

EMPIN=F(YIN, YIN(-1)/EMPIN(-1))

Employment in Tertiary Industry

EMPSRV=F(YSRV, YSRV(-1)/EMPSRV(-1))

Employment in Primary Industry

EMPAG=EMP-EMPIN-EMPSRV

2.5 Energy Demand Block

In the energy demand block, total energy demand in each industry is determined by real output and the aggregate energy price in each sector. The individual energy share of the total energy demand is determined by real output and individual energy prices. The aggregate energy demand and individual energy share of the total economy are the sum of the three industries.

Total Energy Demand in Primary Industry
EENERAG=F(YAG, PENERAG)
Coal Demand in Primary Industry
ECOALAG=F(YAG, PCOAL, ECOALAG(-1))
Oil Demand in Primary Industry
EEOILAG=F(YAG, POIL, PCOAL)
Electricity Demand in Primary Industry
EELECAG=EENERAG-ECOALAG-EEOILAG
Total Energy Demand in Secondary Industry
EENERIN=F(YIN, PENERIN)
Coal Demand in Secondary Industry
ECOALIN=F(YIN, PCOAL, ECOALIN(-1))
Oil Demand in Secondary Industry
EEOILIN=F(YIN, POIL, PCOAL)
Electricity Demand in Secondary Industry
EELECIN=EENERIN-ECOALIN-EEOILIN
Total Energy Demand in Tertiary Industry
EENERSRV=F(YSRV, PENERSRV)
Coal Demand in Tertiary Industry
ECOALSRV=F(YSRV, PCOAL, ECOALSRV(-1))
Oil Demand in Tertiary Industry
EEOILSRV=F(YSRV, POIL, PCOAL)
Electricity Demand in Tertiary Industry
EELECSRV=EENERSRV-ECOALSRV-EEOILSRV

2.6 Environmental Block

At present, the environmental block mainly considers energy-related CO_2 emissions. We evaluate CO_2 emissions in primary, secondary and tertiary industry based on different kinds of energy demand and corresponding coal CO_2 emission factors (FCCO2), oil CO_2 emission factors (FOCO2), and electricity CO_2 emission factors (FECO2). The CO_2 emissions in the total economy are the sum of the three industries.

3. Data and Estimated Results of the Structure Equations

The sources of the data required for an estimation of the macro- and environmental model in 1980-1998 are mainly the World Bank Database (2000), the China Statistical Yearbook (2001), the China Energy Statistical Yearbooks (1989, 1990, 1991-96, 1999) and the China Input-Output Tables (1992, 1995) issued by the China Statistical Publishing House.

Three kinds of final energy consumption are considered in our study: coal, oil and electricity. Coal includes raw coal, cleaned coal, other washed coal, coke oven gas, other gas, and other coking products; oil includes crude oil, gasoline, kerosene, diesel oil, fuel oil, PLG, refinery gas, other petroleum products, and natural gas; electricity includes hydro power, thermal power, nuclear power, and heat. The final energy data are given in coal-equivalent units for the different sectors: agricultural, industrial, and service sector data since 1991 are available from the China Energy Statistical Yearbook (1991-1996, 1999). The final energy data from 1980 to 1990 in physical units are available from the China Energy Statistical Yearbook (1989, 1990). Using the basic data and conversion factors listed in Table 1, we convert the final consumption of different types of fuels from physical units into coal-equivalent units, with electricity calculated using average fuel inputs for thermal power generation in each year.

Table 1 Conversion Factors from Physical Units to Coal Equivalent

Energy	Average Low Calorific Value	Conversion Factor
Crude oil	10000 Kcal/kg	1.4286 Kgce/Kg
Fuel oil	10000 Kcal/kg	1.4286 Kgce/Kg
Gasoline	10300 Kcal/kg	1.4714 Kgce/Kg
Kerosene	10300 Kcal/kg	1.4714 Kgce/Kg
Diesel	10200 Kcal/kg	1.4571 Kgce/Kg
Liquefied Petroleum Gas	12000 Kcal/kg	1.7143 Kgce/Kg
Refinery Gas	11000 Kcal/kg	1.5714 Kgce/Kg
Natural Gas	9310 Kcal/kg	1.3300 Kgce/Kg
Heat		0.03412 Kgce/Mjoule

To construct coal, oil and electricity energy prices in the industrial sectors, we employed the ex-factory price indices of the power, coal, and petroleum sectors to calculate three kinds of energy price index. With intermediate input values of coal, oil and electricity in the agricultural, industrial, and service sectors, the energy price time series data are finally set up for each sector. For the industry sector, we excluded the energy inputs in its energy sectors.

Structural equations of the model are estimated by the Ordinary Least Squares method, and autoregressive errors are adjusted if necessary. Time series data for the estimate cover the period from 1980 to 1998. The estimated results of the macro- and environmental econometric model are shown in the Appendix.

4. Final Test and Simulation with the Model

4.1 Final Test of the Model

Before conducting a simulation analysis with the estimated model, the historical explanatory performance of the model was subjected to a final test, and the satisfactory results obtained are shown in Table 2.

4.2 Simulation Analysis

To evaluate the effects of international trade, FDI, and environmental regulations

Table 2 MAPE of Major Variables in Final Test (Unit: %)

CGV	4.322	ECOALAG	4.097	ECOAL	2.140	PPI80	2.740
CP	3.027	ECOALIN	2.563	EELEC	4.244	PXGS	3.169
FI	3.635	ECOALSRV	2.835	EEOIL	1.856	PYAG	3.701
GDP	1.542	EELECAG	5.327	EENER	1.831	PYIN	3.073
GDPV	3.368	EELECIN	4.353	EMP	0.148	PYSRV	4.248
GNPV	3.381	EELECSRV	12.104	EMP1	0.971	RPI95	1.499
J	16.473	EENERAG	2.224	EMP2	2.668	XGS	3.547
JV	19.919	EENERIN	2.235	EMP3	2.343	YAG	1.123
KJ	1.802	EENERSRV	0.651	PCP	4.087	YAGV	4.148
MGS	2.887	EEOILAG	2.544	PENER	1.813	YIN	3.197
MRATIO	1.532	EEOILIN	1.687	PFI	4.519	YINV	2.898
PENERIN	0.490	EEOILSRV	4.579	PGDP	3.061	YSRV	1.847
PENERSER	2.264	PENERAG	1.547	PMGS	2.834	YSRVV	5.418

on sustainable development in the Chinese economy, simulation analysis is designed to measure the impact of changes in exogenous variables on the relevant endogenous ones in the model. The key exogenous variables in the Chinese model are money supply (M2), domestic credit (CREDIT), foreign exchange rate (FREXCH), foreign direct investment (FDIR$), world imports (MWT$), world export prices (PEWD$), energy prices, and environmental policy (such as energy tax, carbon tax etc.). The fluctuations in these exogenous variables can cause both direct and indirect changes in the environmental and economic variables through investment, international trade, and various price indices and deflators. Several scenarios that take the single and mixed variations in exogenous variables into consideration are simulated in this study. The detailed scenario descriptions are given below, with simulation results listed in Tables3~7, showing the percentage changes in the relevant variables.

4.2.1 Foreign direct investment and the foreign exchange rate

The impacts of foreign direct investment and the foreign exchange rate are simulated in scenarios 1 and 2, respectively. Foreign direct investment received in US dollars is set at a 10% higher level, while the Yuan exchange rate is set to depreciate by 10% from its historical path, with other exogenous variables following the historical path. Both the larger inflow of foreign direct investment and the devaluation of the Yuan exchange rate are expected to result in higher domestic fixed investment, which in turn encourages imports and exports with a time lag.

The simulation results in Table 3 show the positive effect of both the FDI increment and Yuan depreciation on the Chinese economy as well as the negative effects on environmental change. The larger permanent FDI inflows increase GDP by 0.2-0.8% in the short run, and 1.2-2.2% in the long run. The positive impact of FDI on international trade increases imports from 1% to 5%, and exports from 0.7% to 1.0%. The effects of a 10% cut in the Yuan on GDP and exports are more significant than those in scenario 1. However, the opposite case is observed when fixed investment and imports are considered, where the impact of Yuan depreciation is about 40% lower than that of the FDI rise. These results are highly dependent on the specifications of the model used for simulation. Table 4 presents a comparison of the FDI and Yuan exchange rate effects on macro-economic variables in different models.

Table 3 Simulation Experiments (Scenarios 1 and 2)* (Unit: %)

Year	Scenario 1					Scenario 2				
	FI	GDP	MGS	XGS	CARBON	FI	GDP	MGS	XGS	CARBON
1985	0.229	0.119	0.521	0.725	0.133	0.226	0.453	-0.285	7.185	0.520
1986	0.348	0.227	0.769	0.885	0.236	0.318	0.732	-1.317	8.145	0.784
1987	0.441	0.323	1.011	0.924	0.317	0.373	0.904	-1.972	7.868	0.921
1988	0.531	0.403	1.121	0.936	0.380	0.419	0.989	-1.906	7.449	0.970
1989	0.632	0.470	1.092	0.941	0.436	0.468	1.077	-2.089	7.096	1.052
1990	0.724	0.529	1.304	0.944	0.493	0.506	1.160	-2.209	6.827	1.143
1991	0.753	0.585	1.347	0.947	0.524	0.512	1.202	-1.773	6.625	1.140
1992	1.236	0.778	2.682	0.953	0.683	0.938	1.342	-0.291	6.474	1.227
1993	2.080	1.198	4.840	0.963	1.011	1.707	1.696	2.361	6.366	1.471
1994	2.872	1.690	6.309	0.978	1.375	2.430	2.097	3.434	6.291	1.751
1995	3.000	1.961	5.816	0.993	1.535	2.530	2.386	3.285	6.243	1.927
1996	2.991	2.108	5.632	1.007	1.593	2.501	2.546	3.433	6.213	1.989
1997	2.945	2.189	5.541	1.018	1.616	2.443	2.653	3.606	6.193	2.024
1998	2.770	2.201	5.350	1.025	1.593	2.256	2.666	3.541	6.176	1.993
AV	1.539	1.056	3.095	0.946	0.852	1.259	1.564	0.558	6.797	1.351

*Scenario 1: FDI 10% rise; Scenario 2: Yuan 10% depreciation

Table 4 Simulation Experiments by Project Link China Model* (Unit: %)

Year	Scenario 1		Scenario 2	
	FI	GDP	FI	GDP
1988	0.77	0.40	1.29	1.21
1989	0.55	0.33	1.13	1.01
1990	0.80	0.42	1.23	1.50
1991	0.79	0.44	1.35	1.57
1992	1.15	0.54	1.44	1.65
1993	1.90	0.69	1.50	1.69
1994	2.81	0.90	1.64	1.84
1995	2.10	0.77	1.92	2.16
1996	2.30	0.82	1.90	2.15

*Source: Wang Huitong (1999)

With regard to the issue of whether a FDI increase or Yuan devaluation will lead to more carbon emissions than in the baseline scenario in various sectors, in general, Yuan depreciation has a slightly greater effect on carbon emissions than FDI changes. In the short run, a 10% depreciation in the Yuan induces a several times greater increase in carbon emissions than a 10% higher FDI. In the long run, both scenarios show similar effects on environmental change in the simulation.

4.2.2 Carbon and energy taxes

The results of the simulation with regard to carbon and energy taxes are described in scenarios 3 and 4 in Table 5. The effects of these taxes on the macro-economy and on industrial environmental variables are evaluated based on the same reduction in carbon emissions (about 3%) as in the Chinese economy on average during 1980-1998. The carbon tax rate is US$2.24/t CO2, and the energy tax on average is about 8% higher than the carbon tax.

Table 5 Simulation Experiments (Scenarios 3 and 4)* (Unit: %)

Scenario 3					Carbon Emissions			
Year	FI	GDP	MGS	XGS	Coal	Electricity	Oil	Total
1985	-0.167	-0.534	0.171	-0.453	-7.967	2.654	9.274	-2.578
1986	-0.355	-0.880	0.496	-0.668	-9.725	3.659	11.101	-3.257
1987	-0.500	-1.122	0.582	-0.763	-10.342	4.007	11.428	-3.502
1988	-0.576	-1.253	0.371	-0.765	-9.767	2.978	10.497	-3.362
1989	-0.683	-1.329	0.224	-0.733	-9.148	1.814	9.744	-3.219
1990	-0.810	-1.454	0.225	-0.808	-10.435	1.439	11.745	-3.692
1991	-0.799	-1.488	0.145	-0.815	-10.321	1.164	11.712	-3.632
1992	-0.833	-1.474	-0.096	-0.777	-9.418	0.288	10.658	-3.387
1993	-0.809	-1.338	-0.497	-0.642	-7.522	-0.300	8.634	-2.720
1994	-0.826	-1.313	-0.595	-0.648	-8.603	-0.274	10.431	-3.017
1995	-0.802	-1.264	-0.597	-0.598	-7.761	-0.376	9.095	-2.774
1996	-0.764	-1.196	-0.608	-0.546	-6.953	-0.737	8.181	-2.486
1997	-0.718	-1.113	-0.602	-0.494	-6.540	-1.575	7.637	-2.273
1998	-0.688	-1.047	-0.583	-0.478	-6.695	-2.030	7.852	-2.247
AV	-0.666	-1.200	-0.097	-0.656	-8.657	0.908	9.856	-3.011
Scenario 4					Carbon Emissions			
Year	FI	GDP	MGS	XGS	Coal	Electricity	Oil	Total
1985	-0.173	-0.559	0.175	-0.469	-7.703	2.451	8.533	-2.590
1986	-0.368	-0.919	0.511	-0.693	-9.428	3.381	10.223	-3.280
1987	-0.519	-1.168	0.600	-0.789	-10.038	3.724	10.517	-3.526
1988	-0.595	-1.299	0.379	-0.788	-9.481	2.775	9.646	-3.375
1989	-0.703	-1.373	0.226	-0.753	-8.880	1.684	8.944	-3.224
1990	-0.832	-1.497	0.225	-0.826	-10.131	1.368	10.789	-3.687
1991	-0.818	-1.528	0.144	-0.831	-10.017	1.106	10.784	-3.621
1992	-0.850	-1.509	-0.101	-0.790	-9.134	0.260	9.816	-3.371
1993	-0.823	-1.365	-0.507	-0.651	-7.288	-0.341	8.014	-2.705
1994	-0.840	-1.340	-0.607	-0.657	-8.334	-0.363	9.736	-3.012
1995	-0.814	-1.288	-0.608	-0.606	-7.515	-0.465	8.504	-2.766
1996	-0.772	-1.212	-0.616	-0.548	-6.726	-0.727	7.640	-2.453
1997	-0.726	-1.130	-0.611	-0.500	-6.325	-1.600	7.132	-2.270
1998	-0.699	-1.067	-0.594	-0.487	-6.474	-2.038	7.327	-2.251
AV	-0.681	-1.232	-0.099	-0.670	-8.391	0.801	9.115	-3.009

*Scenario 3: Carbon tax US$2.24/tCO2; Scenario 4: Energy tax US$22.2/tCO2

From these comparative results, it is clear that there is no obvious difference between imposing a carbon tax and an energy tax. Both kinds of tax resulted in an average decrease in GDP, international trade and fixed investment of 1.2%, 0.6%, and 0.7%, respectively, during the study period. The environmental taxes will result in a greater carbon emission reduction from reduced coal demand (more than 8%) and an increase from oil demand (more than 9%) in the total Chinese economy.

The effect of an environmental tax on carbon emissions from electricity demand takes a different trajectory, i.e., the carbon emissions increase in the short run but decrease in the long run, ranging from 4% to -2.2% in the total economy. In the industrial sector, both carbon taxes and energy taxes raise the increments of carbon emissions from electricity demand in the short run but lower them in the long run. In other sectors, carbon emissions from electricity demand decrease in all years. The main reason for this is that the substitution elasticity between oil and coal is higher in the agriculture and service sectors than in the industrial sector. The altered trajectory of carbon emissions is similar to the change in the energy demand trajectory.

Table 6 Comparison of Carbon Tax Effect on Different Economies* (Unit: %)

	China		Taiwan	Japan
	(1)	(2)		
CO_2 tax, /ton CO_2	US$2.24	US$2.24	US$2.24	3000Yen
Energy price change rate, %	10.27～23.37	10.27～23.37	0.90～5.79	3.26
Energy demand change rate, %	-2.26	-1.45	-2.52～-7.67	-0.85
CO_2 emissions change rate, %	-3.01	-2.18	-3.95	-1.24
GDP change rate, %	-1.20	-0.16	-0.10	-0.39
Observation period, year	1985-98	1985-98	1999	1990-2005

*The results are estimated by Chi-Yuan Liang for Taiwan, and by Uchida Mitsuho for Japan. China (1) considers carbon tax effect only; China (2) considers both carbon tax and FDI effects.

Table 6 depicts a comparison of carbon tax effects on the macro-economy and environmental changes. With a carbon tax imposed, energy demand and CO_2 emissions decrease by 2.26% and 3.01% respectively for China's economy, compared with 2.52-5.79% and 3.95% for Taiwan's economy. However, for Japan, although a higher carbon tax is imposed, energy demand and CO_2 emissions decrease by only 0.85% and 1.24% respectively. Studies show that with a carbon tax imposed, domestic prices in China increase more than 10% from the baseline level, which may be the main reason behind the 1.20% reduction in real GDP in China. Although carbon taxes affect different economies through different channels, it seems that environment improvements mandated by environmental regulations will cause a fall in economic growth. To keep developing economies on a path towards sustainable development, both economic and environmental policies should be taken into consideration in the future.

4.2.3 The disparate impacts of international trade, FDI and environmental regulation

Table 7 shows the results of the simulation of the disparate impacts of international trade, FDI and environmental regulations on China's macro-economy and environment. Scenarios 5 and 6 simulate the disparate effects of an environment tax and foreign direct investment, while scenarios 7 and 8 simulate those of an environmental tax and the foreign exchange rate.

In scenarios 5 and 6, both the disparate effects of the carbon tax with FDI and those of the energy tax with FDI have a long-term effect on all macro variables and most of the environmental variables. The impacts on GDP and fixed investment are negative in the short run but positive in the long run. Imports, which increase by 1-5%, seem more sensitive than exports, which increase by 0.2-0.5%, suggesting an enhanced import dependency.

Table 7 Simulation Experiments (Scenario 5)* (Unit: %)

Year	FI	GDP	MGS	XGS	YAG	YIN	YSRV	Carbon Emissions			
								Total	Coal	Elec	Oil
1985	0.061	-0.416	0.688	0.270	-0.492	-0.425	-0.320	-2.449	-7.828	2.792	9.353
1986	-0.009	-0.656	1.256	0.211	-0.634	-0.687	-0.642	-3.030	-9.483	3.902	11.245
1987	-0.063	-0.803	1.580	0.154	-0.728	-0.819	-0.857	-3.196	-10.018	4.334	11.625
1988	-0.050	-0.856	1.476	0.164	-0.754	-0.831	-0.980	-2.994	-9.377	3.369	10.731
1989	-0.057	-0.867	1.302	0.201	-0.737	-0.818	-1.036	-2.796	-8.696	2.265	10.008
1990	-0.094	-0.933	1.510	0.128	-0.808	-0.875	-1.108	-3.215	-9.935	1.965	12.044
1991	-0.055	-0.912	1.472	0.124	-0.802	-0.794	-1.146	-3.125	-9.789	1.723	12.030
1992	0.390	-0.708	2.546	0.169	-0.717	-0.406	-1.095	-2.724	-8.711	1.003	11.063
1993	1.250	-0.156	4.281	0.315	-0.406	0.440	-0.830	-1.733	-6.436	0.718	9.209
1994	2.018	0.355	5.633	0.325	-0.226	1.186	-0.525	-1.681	-7.156	1.146	11.234
1995	2.171	0.672	5.148	0.389	0.004	1.508	-0.266	-1.278	-6.142	1.216	9.990
1996	2.201	0.887	4.961	0.456	0.162	1.671	0.013	-0.928	-5.279	0.948	9.105
1997	2.204	1.052	4.883	0.519	0.300	1.764	0.269	-0.692	-4.841	0.148	8.576
1998	2.060	1.130	4.715	0.542	0.360	1.776	0.463	-0.688	-5.030	-0.292	8.794
AV	0.859	-0.158	2.961	0.283	-0.391	0.192	-0.576	-2.181	-7.766	1.802	10.358

Table 7 Continued (Scenario 5) Carbon Emissions

Year	Agriculture Sector				Industry Sector				Service Sector			
	Total	Coal	Elec	Oil	Total	Coal	Elec	Oil	Total	Coal	Elec	Oil
1985	-3.749	-10.972	-18.748	32.631	-2.469	-7.903	7.436	2.542	-1.507	-5.739	-56.182	19.821
1986	-4.764	-17.249	-21.914	39.144	-3.030	-9.375	9.247	2.964	-2.025	-6.920	-45.975	24.093
1987	-5.199	-20.428	-18.986	40.868	-3.183	-9.800	9.645	3.044	-2.186	-7.290	-39.025	25.205
1988	-5.177	-21.052	-16.044	37.190	-2.930	-9.088	8.168	2.745	-2.315	-6.759	-35.747	22.655
1989	-5.008	-20.542	-15.395	33.755	-2.702	-8.387	6.865	2.472	-2.363	-6.229	-33.112	20.318
1990	-5.676	-21.732	-19.053	39.664	-3.063	-9.649	7.777	2.908	-3.020	-7.244	-49.295	24.357
1991	-5.631	-22.142	-18.756	39.310	-2.947	-9.484	7.675	2.934	-3.144	-7.166	-42.550	24.032
1992	-5.216	-21.406	-17.875	35.483	-2.497	-8.456	6.698	2.800	-3.184	-6.510	-42.258	21.410
1993	-4.203	-18.880	-16.568	27.778	-1.475	-6.161	5.141	2.590	-2.571	-5.016	-27.029	16.222
1994	-4.046	-19.008	-16.951	34.000	-1.388	-6.899	6.833	3.452	-2.796	-5.816	-45.874	20.249
1995	-3.457	-17.974	-13.572	30.152	-0.939	-5.855	6.270	3.281	-3.059	-5.053	-46.124	17.764
1996	-3.291	-16.541	-12.778	26.563	-0.537	-5.017	5.495	3.033	-3.009	-4.373	-48.464	15.591
1997	-2.531	-15.307	-11.621	24.685	-0.446	-4.548	3.726	2.910	-1.835	-3.954	-31.480	14.486
1998	-2.364	-14.908	-11.470	25.418	-0.494	-4.708	3.854	2.970	-1.283	-3.999	-22.403	15.025
AV	-4.308	-18.439	-16.409	33.331	-2.007	-7.524	6.774	2.903	-2.450	-5.862	-40.394	20.088

*Scenario 5: Carbon tax US$2.24/tCO2 and FDI 10% rise

The simulation results show that carbon emissions from coal drop by about 8%, while carbon emissions from oil consumption rise by more than 10% in the Chinese economy as a whole. Carbon emissions from electricity present a short-term response in these two scenarios in the economy as a whole. In the industrial sector, carbon emissions from electricity increase by 7%, but decrease by 16% and 40% in the agricultural and service sectors, respectively. Carbon-emission shifts away from coal and oil in all sectors are the same as in the economy as a whole.

The simulations in scenarios 7 and 8 indicate that the mix of environmental tax with foreign exchange rate has almost the same impact on macro- and environmental variables as the mix of environmental tax with foreign direct investment. The sole difference is that in scenarios 7 and 8, exports, which increase by 6% during the study period, seem more sensitive than imports, which decrease by 1% in the short run and increase by 3% in the long run, suggesting an enhanced export dependency.

4.2.4 The simulation of efficiency improvement in energy utilization

The well-known fact that coal accounts for about 70% of total energy consumption and 90% of transformation input for electricity production in the Chinese economy is regarded as the main reason for worsening air pollution. Therefore, the development and utilization of clean coal technologies have been given a higher priority. In particular, to control coal-related pollution from combustion sources such as power plants, Circulating Fluidized Bed Combustion, Pressurized Fluidized Bed Combustion, and Integrated Gasification Combined Cycle systems have been promoted. These technologies are expected to improve energy efficiency and mitigate environmental degradation. In scenario 9, we simply simulate the effect of electricity CO_2 emission factors (FECO2) on carbon emissions, in which FECO2 is assumed to be 10% lower than the baseline level based on the energy efficiency improvement in energy transformation processes. The simulation results indicate that carbon emissions can drop by 3% in the economy as a whole, as seen in scenarios 3 and 4 in which only an environmental tax is imposed. This implies that energy efficiency plays an important role in environmental change, and that its improvement can permit the easing of environmental regulations, making sustainable development a more achievable goal.

4.2.5 Forecasts of economy, energy demand and carbon emissions to the year 2020

To understand future changes in China's economy, energy demand and environmental status, we use the econometric model to forecast endogenous variables under a variety of settings of exogenous variables. The assumed variety of main exogenous variables is listed in Table 8.

Table 8 Average Growth Rate of Main Exogenous Variables (Unit: %)

Variable	2000-2010	2010-2020
FDIR$	10	10
PELE	6	6
POIL	3	3
PCOAL	4	4
PPIFP	3	3
PEWD$	3	3
LF	0.79	0.62
M2	10	7
MWT$	5	5
NYFC	10	10
CREDIT	10	7
FELECO2	0.5	0.5

Table 9. Economic Growth, Energy Demand and Carbon Emissions Under Different Models for 2000-2020: China Data (Unit: %)*

Variable	This Study		Yamada		IEA		IEEJ		Li Zhidong		China Team		Zhou	
	00-10	10-20	00-10	10-20	97-10	10-20	00-10	10-20	99-10	10-20	99-10	10-20	99-10	10-20
CP	6.83	4.91	6.45	3.85										
FI	6.94	5.59	6.43	4.47										
XGS	9.62	5.64	8.97	6.31										
MGS	6.54	5.99	9.12	5.68										
GDP	7.01	5.26	6.11	4.40	6	3.71	7.1	6.1	7.4	6.1	9.2	5.3	8.6	6
EENER	4.22	3.11	5.30	3.01	3.56	3.11	3.23	3.84	3.7	3.6	4.1	1.7	3.9	2.1
ECOAL	3.82	2.55	5.43	2.76	2.73	2.4	1.94	2.64	2.68	2.53				
EEOIL	4.00	3.44	4.81	3.43	4.83	3.84	3.83	4.34	4.06	4.4				
EELEC	4.90	3.67	4.92	3.63	5.76	4.36	5.99	6.59						
TOTALCO2	4.02	2.87	3.68	2.92					3.2	3.22				
TOTALCCO2	3.82	2.55	3.27	2.72					2.68	2.52				
TOTALOCO2	4.00	3.44	4.92	3.43					4.2	4.48				
TOTALECO2	4.38	3.15												

*Case 4(IEEJ) is estimated by the Institute of Energy Economics, Japan.

The forecast output in our study and a comparison with other studies are presented in Table 9. The results in our study show that the average annual growth rate of GDP will be 7% in 2000-2010 and 5.26% in 2010-2020. Private consumption and fixed investment will grow by more than 6% in the former decade and 5% in the latter. The growth rates of exports and imports, respectively, will be 9.62% and 6.54% from 2000 to 2010, and 5.64% and 5.99% from 2010 to 2020. That means that the Chinese economy will pass from export dependency to import dependency. Total carbon emissions will increase by 4% and 3% on average over the two decades. Carbon emissions from oil and electricity consumption will contribute more than that from coal consumption. Compared with other studies, our forecast results of GDP growth rate are 6-9% in 2000-2010 and 4-6% in 2010-2020. Total carbon emissions will grow 3-4% during those forecast periods. These results are highly related to the specifications of the model used for forecasting. For example, in the Yamada and Li models, gross domestic product is determined by demand factors, and primary energy consumption and supply are obtained by aggregating the energy requirements from the end-use and transformation sectors. However, in our model, GDP is determined by the supply side; that is, the aggregation output of three industry sectors and three kinds of final energy demand are considered. The prices of different energy types are treated as exogenous variables, and the aggregate energy price is endogenous in our model, whereas the energy price index is solved as an endogenous variable in other models.

The forecast for the carbon tax effect to the year 2020 is presented in Table 10. When a carbon tax (2.24$/t CO2) is imposed, the GDP will decrease by 0.77% on average in the first ten years, and by 0.49% in the following ten years. Energy demand will also shift from coal to oil and electricity, and carbon emissions will fall by 1.82% and 3.81%, respectively, in the first and second forecast periods.

Table 10 Forecast of Carbon Tax Effect to 2020 (Unit: %)

Variable	95-00	00-10	10-20	Variable	95-00	00-10	10-20
CP	-1.123	-0.821	-0.527	AGRCO2	-3.642	-2.472	-1.630
FI	-0.717	-0.545	-0.369	AGRCCO2	-16.713	-13.760	-9.979
GDP	-1.099	-0.765	-0.487	AGRECO2	-12.878	-7.134	-3.933
MGS	-0.597	-0.549	-0.413	AGROCO2	26.321	20.992	14.374
XGS	-0.508	-0.368	-0.241	INDCO2	-2.277	-1.887	-1.325
YAG	-0.840	-0.706	-0.505	INDCCO2	-6.708	-5.338	-3.711
YIN	-1.037	-0.686	-0.423	INDECO2	3.820	4.482	3.378
YSRV	-1.367	-0.936	-0.600	INDOCO2	1.885	1.582	1.111
TOTALCO2	-2.394	-1.820	-1.221	SERCO2	-2.784	-1.223	-0.635
TOTALCCO2	-6.892	-5.463	-3.809	SERCCO2	-4.955	-3.901	-2.678
TOTALECO2	-0.568	0.564	0.208	SERECO2	-33.154	-13.016	-7.063
TOTALOCO2	8.097	6.522	4.727	SEROCO2	15.062	11.896	8.018

5. Concluding remarks

We have examined the effects of international trade, FDI, and environmental regulations on sustainable development under a Chinese macro-econometric model framework. Both single and mixed variations of exogenous variables are taken into consideration in our simulation scenarios.

The simulation results show the positive effects of both FDI increments and Yuan depreciation on the Chinese economy, and their negative effects on the environment. A 10% depreciation in the Yuan induces higher carbon emissions than a 10% increase in foreign direct investment in the short run, with almost the same emissions in the long run. In contrast, the simulation scenarios for environmental regulations show that carbon and energy taxes lead to a drop in both economic growth and carbon emissions. Environmental taxes result in carbon emission decrements from coal demand and carbon emission increments from oil demand. However, they result in increments from electricity demand in the short run and decrements in the long run. The disparate changes in international trade and environmental regulations indicate that the economy shrinks in the short run and grows in the long run, but that carbon emissions decline during the sample period in our simulation scenarios. The simulation scenario regarding energy efficiency improvements in power generation processes shows that carbon emissions can drop by 3% in the economy as a whole, as long as an environmental tax is imposed. This implies that energy efficiency plays an important role in environmental change, and that its improvement can help to ease environment regulations and make sustainable development more possible. We also made forecasts for economic growth, energy demand and carbon emissions to 2020. Our results show that the average annual growth rate of GDP will be 7% in 2000-2010, and 5.26% in 2010-2020. Total carbon emissions will increase by 4% and 3% on average, respectively, in those two decades. Carbon emissions from oil and electricity consumption are higher than those arising from coal consumption. In trying to maintain a sustainable development path, a developing economy can afford to ignore neither economic nor environmental policies.

Note

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Appendix

Ⅰ. Estimated Results of Macro and Environment Econometric Model

Aggregate Demand Block

GDP=CP+CGV*100/PCG+FI+J+XGS-MGS+EPSV*100/PGDP

CP=29.8163*(GNPV/PCP)+0.3650*CP(-1)+79.7082
(6.1785) (3.1929) (3.1832)
R^2=0.997 SE=48.265 DW=1.412

CGV=0.1344*(GNPV-GNPV(-1))+0.1163*GNPV(-1)+12.4119
(10.2881) (52.7853) (2.6466)
R^2=0.997 SE=14.673 DW=1.212

FI=208.1652+0.4696*FI(-1)-116.6302*(D85(-4)+D90)
(3.3873) (2.5667) (-2.3332)
+10.6202*(CREDIT/PFI)+0.1225*(FDIR$*FREXCH/PFI)
(3.0785) (2.8038)
R^2=0.993 SE=58.870 DW=1.243

J=0.3160*GDP(-1)-0.1833*(GDP(-1)*GDP(-1)/10000)-0.1738*KJ(-1)
(3.8623) (-4.2764) (-2.3380)
-204.1438
(-2.6193)
R^2=0.823 SE=42.029 DW=1.529

JV=-0.1473+1.0061*(J*PPI80/338.1)-80.6323*(D90(-7)+D90(-8))
(-0.0817)(111.5486) (-28.4247)
R^2=0.999 SE=3.1481 DW=1.986

LOG(XGS)=-7.6671+1.3114*LOG(MWT$)
(-5.9463)(6.6542)
-0.7373*LOG(PXGS/FREXCH/PEWD$)
(-6.6444)
+0.0377*(LOG(FDIR$*FREXCH/PFI)
(3.1422)
+LOG(FDIR$(-1)*FREXCH(-1)/PFI(-1)))
+0.2151*LOG(XGS(-1))
(2.0340)
R^2=0.998 SE=0.0359 DW=1.960

MGS=676.4988+0.0909*GDP-578.4436*(PMGS/PGDP)
(8.6688) (6.7840) (-6.9368)
+0.2019*(FDIR$*FREXCH/PGDP)+112.9875*(D90(-1)+D90(-2))
(11.3091) (5.3697)
R^2=0.997 SE=22.846 DW=2.701

KJ=KJ(-1)+J

EPSV=GDPV-(CP*PCP+CGV+FI*PFI+JV+XGS*PXGS/100-MGS*
PMGS/100)

Output and Income Block

GNPV=GDPV+NYFC
GDP=YAG+YIN+YSRV
GDPV=YAGV+YINV+YSRVV
YAGV=YAG*PYAG/100
YINV=YIN*PYIN/100
YSRVV=YSRV*PYSRV/100

YAG=161.8644+0.1779*CP+0.4718*LF+0.04176*EENERAG
(3.0086) (14.2164) (4.9215) (2.6806)
R^2=0.996 SE=11.240 DW=1.815

YIN=-248.2727+0.4799*FI+0.2661*XGS+0.1452*MGS
(-1.4983) (6.1459) (2.6176) (1.9421)
+0.4571*YIN(-1)+0.4871*EENERIN/100+[AR(1)=0.7624]
(6.0241) (1.8464) (3.7159)
R^2=0.999 SE=23.699 DW=1.718

YSRV=-267.5852+0.5075*YAG+0.07402*YIN+0.5763*YSRV(-1)+
(-3.6928) (3.5353) (2.7015) (5.2359)
0.02291*EENERSRV
(1.7606)
R^2=0.999 SE=21.940 DW=1.657

Price Block

LOG(PENERAG)=0.2140*LOG(PCOALAG)+0.3016*LOG(PELEAG)+
(1.8977) (3.2372)
0.5676*LOG(POILAG)-0.4756+0.07621*D80
(5.6854) (-5.9598)(2.7027)
-0.05331*D85
(-1.9750)
R^2=0.999 SE=0.0256 DW=1.336

LOG(PENERIN)=0.2842*LOG(PCOALIN)+0.6892*LOG(PELEIN)+
(9.2191) (21.9147)
0.1530*LOG(POILIN)-0.8460-0.03327*(D90(-6)-D98)
(5.0376) (-17.4620)(-5.8235)
R^2=0.999 SE=0.0070 DW=2.231

LOG(PENERSER)=0.4179*LOG(PCOALSER)+0.5805*LOG(PELESER)
(2.9995) (5.1145)
+0.3798*LOG(POILSER)-2.2339
(2.8343) (-10.0571)
R^2=0.999 SE=0.0345 DW=1.414

LOG(PENER)=0.7634*LOG(PENERSER+PENERAG+PENERIN)
(116.7226)
-1.4905
(-32.8458)
R^2=0.999 SE=0.0227 DW=1.585

LOG(PPI)=2.6235+0.1390*LOG(M2/GDP)+0.2687*LOG(PPIFP)+
(5.1022)(1.8826) (2.1192)
0.2749*LOG(PMGS)+0.1498*LOG(PENER)-0.0948*D85(-2)
(2.7065) (1.8499) (-2.0085)
R^2=0.992 SE=0.0431 DW=2.074

RPI=6.7011+0.08143*PPIFP+0.1657*PPI+0.3336*RPI(-1)
(17.1118)(2.2973) (14.0416) (14.7331)
+1.8846*D85(-3)+4.1663*D85(-4)+2.3687*(D90+D90(-1))
(3.2748) (7.4097) (6.0868)
R^2=0.999 SE=0.4942 DW=2.377

PCP=0.7657*RPI-6.4672+0.3196*PCP(-1)+[AR(1)=0.5029]
(5.6132) (-2.3832)(2.4526) (2.0042)
R^2=0.994 SE=2.2025 DW=1.698

LOG(PFI)=1.7425+0.7198*LOG(RPI)+0.3345*LOG(FI/GDP)
(1.2298)(2.9781) (1.9195)
+[AR(1)=0.9248]
(7.8438)
R^2=0.992 SE=0.0401 DW=1.547

LOG(PXGS)=-0.4315+0.3854*LOG(PPI80)+0.6010*LOG(PMGS)-
(-3.7970)(5.8735) (9.8980)
0.09423*D85(-4)-0.07001*(D90(-3)-D90(-4))
(-4.5288) (-4.6943)
R^2=0.999 SE=0.0181 DW=2.502

LOG(PMGS)=-0.6460+0.3247*LOG(PEWD$)
(-1.2232)(2.5405)
+0.1658*LOG(FREXCH)+0.7383*LOG(PMGS(-1))
(3.0150) (15.4697)
+0.3259*D90(-4)-0.1733*(D85-D85(-1))
(6.7469) (-5.6962)
R^2=0.994 SE=0.0410 DW=2.190

PYAG=-8.9457+0.9446*PGDP+0.1641*PYAG(-1)
(-11.0852)(19.2740) (3.4970)
-5.1558*(D90(-3)+D90(-2))
(-5.5049)
R^2=0.998 SE=1.192 DW=2.375

PYIN=13.1007+0.8675*PGDP-4.6321*D90(-8)
(17.9502)(84.6531) (-4.6115)
R^2=0.998 SE=0.889 DW=1.694

PYSRV=-11.9541+1.1945*PGDP-7.7238*(D90(-5)+D90(-6)+D90(-7))
(-8.7881)(54.2251) (-5.4199)
R^2=0.997 SE=1.554 DW=1.668

PGDP=0.8631+0.5488*PCP+0.4011*PFI+0.2505*PXGS-0.2141*PMGS
(1.7153)(19.3080) (13.3095) (1.8255) (-1.5047)
R^2=0.999 SE=0.6487 DW=2.146

Employment Block

LOG(EMP)=1.0687*LOG(LF)-0.02292*LOG(GDP(-1)/EMP(-1))
(62.8239) (-4.6874)
+4.0994-0.01445*D9098
(34.2504)(-4.4069)
R^2=0.999 SE=0.0019 DW=1.298

LOG(EMP2)=2.3759+0.7648*LOG(YIN)-0.6651*LOG(YIN(-1)/
(5.77478)(20.6990) (-10.2222)
EMP2(-1))+0.1662*D90
(6.4922)
R^2=0.993 SE=0.0249 DW=1.898

LOG(EMP3)=3.0074+0.5108*LOG(YSRV)-0.4391*LOG(YSRV(-1)/
(4.4746)(2.5909) (-3.1391)
EMP3(-1))+0.09732*D9098+0.2407*LOG(YSRV(-1))
(3.7817) (1.1053)
R^2=0.996 SE=0.0284 DW=1.586

EMP1=EMP-EMP2-EMP3

Energy Demand Block

LOG(EENERAG)=0.9311*LOG(YAG)-0.07357*LOG(PENERAG)
(11.3014) (-3.0538)
+2.4400-0.07757*(D90(-3)+D80(-4))
(5.3845)(-4.1684)
R^2=0.976 SE=0.0247 DW=2.106

LOG(ECOALAG)=0.5896*LOG(YAG)-0.2482*LOG(PCOALAG)
(2.1022) (-2.3263)
+0.9142+0.4604*LOG(ECOALAG(-1))
(1.2270)(2.5410)
-0.1585*D90(-2)-0.1068*D90(-3)
(-3.0620) (-2.0475)
R^2=0.836 SE=0.0491 DW=1.941

LOG(EEOILAG)=5.2210-0.3646*LOG(POILAG)
(7.7783)(-2.0764)
+0.6814*LOG(PCOALAG)+0.2168*LOG(YAG)
(2.6985) (1.8103)
-0.1440*D85
(-2.6771)
R^2=0.929 SE=0.0513 DW=1.239

LOG(EENERIN)=0.5962*LOG(YIN)-0.1190*LOG(PENERIN)+7.4018
(22.6183) (-4.5346) (107.9887)
-0.1262*D98
(-5.2929)
R^2=0.996 SE=0.0209 DW=1.785

LOG(ECOALIN)=6.7911+0.6688645977*LOG(YIN)
(68.8820)(18.1640)
-0.2640*LOG(PCOALIN)-0.3055*D98-0.1498*D97
(-6.3245) (-11.8316) (-5.7213)
R^2=0.993 SE=0.0225 DW=1.357

LOG(EEOILIN)=6.3319-0.1088*LOG(POILIN/PCOALIN)
(110.9392)(-2.1530)
+0.4181*LOG(YIN)+0.1288*D80-0.06665*D93
(25.7887) (5.7191) (-3.1891)
R^2=0.994 SE=0.0200 DW=1.918

EENERSRV=1365.5026-0.6407*(PENERSER(-1)
(4.3962) (-2.3056)
-PENERSER(-2))+3.1064*YSRV(-1)
(5.9390)
+0.5570*EENERSRV(-1)+973.7045*(D93-D95)
(5.8095) (8.8806)
-481.7501*(D90+D97)
(-4.2669)
R^2=0.998 SE=142.387 DW=1.449

LOG(ECOALSRV)=6.7633+0.4435*LOG(YSRV)
(30.9109)(6.9157)
-0.3343*LOG(PCOALSER)-0.8042*D98
(-5.9446) (-15.9139)
-0.4763*D97+0.1213*(D90(-4)-D90(-5))
(-9.2918) (3.9072)
R^2=0.966 SE=0.04385 DW=1.605

LOG(EEOILSRV)=3.3301-0.4489*LOG(POILSER)
(15.4454)(-2.1677)
+1.1251*LOG(PCOALSER)+0.3373*LOG(YSRV)
(3.7207) (5.0488)
R^2=0.987 SE=0.05921 DW=1.859

EELECAG=EENERAG-EECOALAG-EEOILAG
EELECIN=EENERIN-EECOALIN-EEOILIN
EELECSRV=EENERSRV-EECOALSRV-EEOILSRV

Environment Block

AGRCCO2=ECOALAG*FCCO2
AGROCO2=EEOILAG*FOCO2
AGRECO2=EELECAG*FECO2
AGRCO2=AGRCCO2+AGROCO2+AGRECO2
INDCCO2=ECOALIN*FCCO2
INDOCO2=EEOILIN*FOCO2
INDECO2=EELECIN*FECO2
INDCO2=INDCCO2+INDOCO2+INDECO2
SERCCO2=ECOALSRV*FCCO2

SEROCO2=EEOILSRV*FOCO2
SERECO2=EELECSRV*FECO2
SERCO2=SERCCO2+SEROCO2+SERECO2
TOTALCO2=AGRCO2+INDCO2+SERCO2
TOTALCCO2=AGRCCO2+INDCCO2+SERCCO2
TOTALOCO2=AGROCO2+INDOCO2+SEROCO2
TOTALECO2=AGRECO2+INDECO2+SERECO2

Ⅱ. Variable List

Endogenous Variables

1. Aggregate Demand Block		
GDP	Real GDP from Demand Side	Billions of Yuan
CP	Real Private Consumption	Billions of Yuan
CGV	Nominal Public Consumption	Billions of Yuan
FI	Real Fixed Investment	Billions of Yuan
J	Real Inventory Investment	Billions of Yuan
JV	Nominal Inventory Investment	Billions of Yuan
XGS	Real Exports	Billions of Yuan
MGS	Real Imports	Billions of Yuan
KJ	Inventory Stock	Billions of Yuan
EPSV	Statistical Discrepancy	Billions of Yuan
MRATIO	Ratio of M2 to GDP	Percent
2. Output and Income Block		
YAG	Real Output of Primary Industry	Billions of Yuan
YIN	Real Output of Secondary Industry	Billions of Yuan
YSRV	Real Output of Tertiary Industry	Billions of Yuan
GDP	Real GDP from Supply Side	Billions of Yuan
YAGV	Nominal Output of Agriculture Sector	Billions of Yuan
YINV	Nominal Output of Industry Sector	Billions of Yuan
YSRVV	Nominal Output of Tertiary Sector	Billions of Yuan
GDPV	Nominal GDP	Billions of Yuan
GNPV	Nominal GNP	Billions of Yuan
3.Price Block		
PENERAG	Aggregate Energy Price in Agriculture Sector	1995=100
PENERIN	Aggregate Energy Price in Industry Sector	1995=100
PENERSER	Aggregate Energy Price in Service Sector	1995=100
PENER	Aggregate Energy Price	1995=100
PPI	Producer Price Index	1995=100
RPI	Retail Price Index	1995=100
PCP	Private Consumption Deflator	1995=100
PFI	Fixed Investment Deflator	1995=100
PXGS	Export Deflator	1995=100
PMGS	Import Deflator	1995=100
PYAG	Output Deflator of Primary Industry	1995=100
PYIN	Output Deflator of Secondary Industry	1995=100
PYSRV	Output Deflator of Tertiary Industry	1995=100
PGDP	GDP Deflator	1995=100
4.Employment Block		
EMP	Total Employment	Million Persons
EMPAG	Employment in Primary Industry	Million Persons
EMPIN	Employment in Secondary Industry	Million Persons
EMPSRV	Employment in Tertiary Industry	Million Persons

5.Energy Demand Block		
EENERAG	Total Energy Demand in Primary Industry	Ten Thousand Tons SCE*
ECOALAG	Coal Demand in Primary Industry	Ten Thousand Tons SCE
EEOILAG	Oil Demand in Primary Industry	Ten Thousand Tons SCE
EELECAG	Electricity Demand in Primary Industry	Ten Thousand Tons SCE
EENERIN	Total Energy Demand in Secondary Industry	Ten Thousand Tons SCE
ECOALIN	Coal Demand in Secondary Industry	Ten Thousand Tons SCE
EEOILIN	Oil Demand in Secondary Industry	Ten Thousand Tons SCE
EELECIN	Electricity Demand in Secondary Industry	Ten Thousand Tons SCE
EENERSRV	Total Energy Demand in Tertiary Industry	Ten Thousand Tons SCE
ECOALSRV	Coal Demand in Tertiary Industry	Ten Thousand Tons SCE
EEOILSRV	Oil Demand in Tertiary Industry	Ten Thousand Tons SCE
EELECSRV	Electricity Demand in Tertiary Industry	Ten Thousand Tons SCE
EENER	Total Energy Demand in Overall Economy	Ten Thousand Tons SCE
ECOAL	Total Coal Demand in Overall Economy	Ten Thousand Tons SCE
EEOIL	Total Oil Demand in Overall Economy	Ten Thousand Tons SCE
EELEC	Total Electricity Demand in Overall Economy	Ten Thousand Tons SCE
6.Environment Block		
AGRCCO2	CO2 Emissions from Coal in Primary Industry	Ten Thousand Tons CO2
AGROCO2	CO2 Emissions from Oil in Primary Industry	Ten Thousand Tons CO2
AGRECO2	CO2 Emissions from Electricity in Primary Industry	Ten Thousand Tons CO2
AGRCO2	Total CO2 Emissions in Primary Industry	Ten Thousand Tons CO2
INDCCO2	CO2 Emissions from Coal in Secondary Industry	Ten Thousand Tons CO2
INDOCO2	CO2 Emissions from Oil in Secondary Industry	Ten Thousand Tons CO2
INDECO2	CO2 Emissions from Electricity in Secondary Industry	Ten Thousand Tons CO2
INDCO2	Total CO2 Emissions in Secondary Industry	Ten Thousand Tons CO2
SERCCO2	CO2 Emissions from Coal in Tertiary Industry	Ten Thousand Tons CO2
SEROCO2	CO2 Emissions from Oil in Tertiary Industry	Ten Thousand Tons CO2
SERECO2	CO2 Emissions from Electricity in Tertiary Industry	Ten Thousand Tons CO2
SERCO2	Total CO2 Emissions in Tertiary Industry	Ten Thousand Tons CO2
TOTALCCO2	CO2 Emissions from Coal in Overall Economy	Ten Thousand Tons CO2
TOTALOCO2	CO2 Emissions from Oil in Overall Economy	Ten Thousand Tons CO2
TOTALECO2	CO2 Emissions from Electricity in Overall Economy	Ten Thousand Tons CO2
TOTALCO2	Total CO2 Emissions in Overall Economy	Ten Thousand Tons CO2

Exogenous Variables

FDIR$	Foreign Direct Investment	Billions of U.S. Dollars
FREXCH	Foreign Exchange Rate	Yuan per U.S. Dollar
FCCO2	Coal CO2 Emission Factor	Tons CO2 per Ton Coal
FOCO2	Oil CO2 Emission Factor	Tons CO2 per Ton Oil
FECO2	Electricity CO2 Emission Factor	Ton CO2 per Ton Electricity
PCOALAG	Coal Price in Primary Industry	1995=100
PCOALIN	Coal Price in Secondary Industry	1995=100
PCOALSER	Coal Price in Tertiary Industry	1995=100
POILAG	Oil Price in Primary Industry	1995=100

POILIN	Oil Price in Secondary Industry	1995=100
POILSER	Oil Price in Tertiary Industry	1995=100
PELEAG	Electricity Price in Primary Industry	1995=100
PELEIN	Electricity Price in Secondary Industry	1995=100
PELESER	Electricity Price in Tertiary Industry	1995=100
LF	Working-age Population	Million Persons
M2	Money Supply Factor	Billions of Yuan
PEWD$	World Export Prices	1995=100
PPIFP	Purchasing Price Index of Food Products	1995=100
MWT$	World Imports	Billions of U.S. Dollars
CREDIT	Financial Availability (Domestic Credit)	Billions of Yuan
NYFC	Net Factor Income from Abroad	Billions of Yuan

*SCE: Standard Coal Equivalent. 70 Endogenous Variables, 19 Exogenous Variables

Japanese Overseas Production within the Asia International Input-Output Model: Japan, the US, and Asia※

Mitsuo Yamada*

Abstract

This paper recompiles the Asian international input-output table for 1995 to analyze the interdependence between Japanese firms, Japanese subsidiaries in the US and Asia, and other companies. We find that the production of Japanese subsidiaries in the US is hardly affected by the situation in Japan as a whole, but depends heavily on the US market. Japanese subsidiaries in Asia have a relatively large interdependence with Japan, especially in the machinery sectors. Overseas production affects the home country in two different ways: the induced production effect and the substitution effect. If the degree of substitution were the same as the ratio of Japanese exports for each sector, production in Japan as a whole would increase when its overseas production grew. However, hollowing-out may occur in the transport equipment sector.

KEYWORDS: *input-output analysis, Japanese overseas production, Asian international input-output table, hollowing-out in the manufacturing sector*

1. Introduction

It is widely known that foreign direct investment (FDI) played an important role in the economic development of the countries of East Asia. After the Plaza Accord was signed in 1985, the rapid appreciation of the Japanese yen forced Japanese manufacturers to extend overseas production. Although the long recession following the collapse of the bubble economy in the 1990s somewhat dampened the enthusiasm of Japanese firms vis-a-vis FDI, the globalization of the Japanese economy seemed a long-term trend. Furthermore, the 1997 Asian financial crisis threw Asian economies into confusion and many firms came to a standstill. However, the following year, Asia's economy recovered gradually and the volume of FDI conducted by Japanese firms also recovered to pre-crisis levels.

The overseas activities of Japanese firms are examined in surveys published by the Ministry of Economy, Trade, and Industry (METI): the *Basic Survey of Overseas Business Activities* every three years and the *Trend Survey of Overseas Business Activities* in other years. According to the reports, there are about 13,000 overseas affiliates of Japanese firms, with sales by these firms reaching 126 trillion yen in 1998 (50 trillion yen in the manufacturing sector and 76 trillion yen in non-manufacturing sectors). The total value of sales accounted for 14.4% of total Japanese output in 1998.

It is well known that input-output analysis is one of the most useful tools for carrying out impact analysis of hollowing-out in the manufacturing sector. According to Inaba (1999), much Japanese research carried out in this field from 1979 to 1995

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involved estimating the effects of FDI on international trade and then evaluating the direct and indirect impacts of this change in international trade on internal production and labor demand. Input-output analysis was applied to this latter phase. There were many disparities in the methods used to link FDI to international trade and in the usage of input-output tables, which led to differences in their results. However, analysis using internal input-output tables cannot completely capture the interdependence between firms based in the home country and their overseas affiliates.

Yamada (2002) modified the 1995 US-Japan international input-output table and analyzed the relationship between the US and Japanese economy by looking at Japanese overseas activities. This analysis explicitly demonstrated the activities of the Japanese overseas firms in the US market in the input-output table, and evaluated the impact of Japanese overseas production in the US economy on both the US and Japanese economies.

In this paper, we will reconstruct the Asian international input-output table for 1995 to extract from it information about Japanese overseas activities in the US and Asian economies, and to integrate those activities into one table. Using this modified table, we are able to analyze the effects of Japanese overseas production in the US and Asian economies on Japan, the US, and Asian economies. We are also able to discuss the differences between Japanese overseas activities in the US and Asian economies.

In the next section, we discuss the theoretical framework of the input-output model in brief. We then state the database for our recompiled input-output table. Finally, we examine some analytical results showing the relationship between those economies and the impact of Japanese overseas activities on each economy.

2. Theoretical framework

As is well known, an international input-output table shows the internal and international transactions among sectors in each country, and is compiled from each country's input-output table and international trade statistics. Here, we consider the international input-output tables of two countries: Japan and the relevant foreign country. Furthermore, we extract the Japanese overseas activity from the foreign country, using the figure 1 to denote Japan, 2 to denote the foreign country excluding Japanese overseas activity, and 3 to denote Japanese overseas activity. Our model is expressed as follows:

$$\begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} F_{11} \\ F_{21} \\ F_{31} \end{bmatrix} + \begin{bmatrix} F_{12} \\ F_{22} \\ F_{32} \end{bmatrix} + \begin{bmatrix} E_1 \\ E_2 \\ E_3 \end{bmatrix} = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}.$$

Here, A_{13}, A_{23}, and A_{33} signify the input coefficient matrices of Japanese overseas activity. Sales of the intermediate products of Japanese overseas activity to each region are expressed as $A_{31}x_1$, $A_{32}x_2$, and $A_{33}x_3$ respectively. Exports of finished goods to the Japanese market are expressed as F_{31} for Japanese overseas activity. On the other hand, the sales value of finished goods in the domestic market is expressed as F_{32}, while exports to a third county are expressed as E_3.

Solving this equation for the output, we obtain

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} I-A_{11} & -A_{12} & -A_{13} \\ -A_{21} & I-A_{22} & -A_{23} \\ -A_{31} & -A_{32} & I-A_{33} \end{bmatrix}^{-1} \begin{bmatrix} F_{11} \\ F_{21} \\ F_{31} \end{bmatrix} + \begin{bmatrix} F_{12} \\ F_{22} \\ F_{32} \end{bmatrix} + \begin{bmatrix} E_1 \\ E_2 \\ E_3 \end{bmatrix}$$

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix} \begin{bmatrix} F_{11} \\ F_{21} \\ F_{31} \end{bmatrix} + \begin{bmatrix} F_{12} \\ F_{22} \\ F_{32} \end{bmatrix} + \begin{bmatrix} E_1 \\ E_2 \\ E_3 \end{bmatrix} .$$

Assuming and $\Delta F_{11} = \Delta F_{12} = \Delta E_1 = 0$ and $\Delta F_{21} = \Delta F_{22} = \Delta E_2 = 0$ in this equation, we can derive the output induced by finished goods resulting from Japanese overseas activity as follows:

$$\begin{bmatrix} \Delta x_1 \\ \Delta x_2 \\ \Delta x_3 \end{bmatrix} = \begin{bmatrix} B_{13}(\Delta F_{31} + F_{32} + \Delta E_3) \\ B_{23}(\Delta F_{31} + F_{32} + \Delta E_3) \\ B_{33}(\Delta F_{31} + F_{32} + \Delta E_3) \end{bmatrix}.$$

This shows the degree to which the induced production in each economy stems from the Japanese overseas production of finished goods.

On the other hand, Japanese overseas production will substitute for domestic final demand and exports from Japan to some extent. If we assume that $100a_i\%$ of Japanese overseas production of finished goods i substitutes for these, that is

$$\Delta F_{11} + \Delta F_{12} + \Delta E_1 = -[a_i](\Delta F_{31} + \Delta F_{32} + \Delta E_3),$$

where $[a_i]$ means a diagonal matrix whose diagonal elements are a_i, then the induced effect on production is derived from the following equation:

$$\begin{bmatrix} \Delta x_1 \\ \Delta x_2 \\ \Delta x_3 \end{bmatrix} = -\begin{bmatrix} B_{11}[a_i](\Delta F_{31} + F_{32} + \Delta E_3) \\ B_{21}[a_i](\Delta F_{31} + F_{32} + \Delta E_3) \\ B_{31}[a_i](\Delta F_{31} + F_{32} + \Delta E_3) \end{bmatrix}.$$

3. Database for the input-output model

The Asian international input-output table for 1995 was compiled and published by the Institute of Developing Economies (IDE) in 2000. This table includes ten countries or regions: Japan, the US, Indonesia, Malaysia, the Philippines, Singapore, Thailand, China, Taiwan, and South Korea. Hong Kong is also included but treated as exogenous. In European countries, the UK, France, and Germany appear as exogenous. IDE Asian international input-output tables were published for 1985, 1990 and 1995. However, we concentrate our attention on the most recent year for which input-output tables exist, because the overseas expansion of Japanese firms has continued to accelerate since 1985.

Firstly we integrate ten countries or regions from this table into three: Japan, the US, and Asia.[1] Then, we recompile the table so that Japanese overseas production activities in the US and Asia are become explicit. Here we use statistics obtained from a survey carried out the same year by METI regarding the overseas activity of Japanese firms. We make use of data on the regional sales volumes of Japanese overseas affiliates by industry, sales for each market, domestic and foreign, and the purchase of intermediate goods and services from each region.[2]

78 sectors are originally defined for each country or region in the IDE table, and it would seem desirable to use the 78-sector table for the analysis. However, the METI data on Japanese overseas activities gives us information for only 18 sectors: agriculture, fisheries and forestry, mining, construction, 12 manufacturing sectors, wholesale and retail trade, services, finance and real estate. Therefore, we have had to integrate the input-output table to create 20 sectors, adding two sectors: the public sector, and others (public utilities and network sector), in which Japanese firms are assumed not to have expanded overseas. The definition of each sector appears in Table 1.

Table 1 Definition of Sectors

	Sectors
1	Agriculture, forestry and fishery
2	Mining
3	Construction
4	Food
5	Textiles
6	Timber, wood, and pulp
7	Chemical Industry
8	Iron and Steel
9	Nonferrous metals
10	General machinery
11	Electrical machinery
12	Transport equipment
13	Precision instruments
14	Petroleum and coal
15	Miscellaneous manufacturing
16	Commerce
17	Public service
18	Other service
19	Finance and real estate
20	Other

The basic idea and detailed procedure for estimating the recompiled input-output table can be found in Yamada (2002). In this paper, we discuss the outline of the procedure. (See Figure 1.)

Figure 1 Recompilation of an International Input-Output Table

(1) Asian international input output table, original

Asian international input output table		Intermediate demand: Japan	Intermediate demand: The United States	Intermediate demand: Asia	Final demand: Japan	Final demand: The United States	Final demand: Asia	Export: ROW	Production
Intermediate Input	Japan	Axjj	Axju	Axja	Fdjj	Fdju	Fdja	Ejr	Xj
	The United States	Axuj	Axuu	Axua	Fduj	Fduu	Fdua	Eur	Xu
	Asia	Axaj	Axau	Axaa	Fdaj	Fdau	Fdaa	Ear	Xa
Import	ROW	Axrj	Axru	Axra	Fdrj	Fdru	Fdra		
Value added		Vj	Vu	Va					
Production		Xj	Xu	Xa					

(2) Separation of activity of Japanese overseas subsidiary

Asian international input output table(non-overseas subsidiary)		Intermediate demand: Japan	Intermediate demand: The United States	Intermediate demand: Asia	Final demand: Japan	Final demand: The United States	Final demand: Asia	Export: ROW	Production
Intermediate Input	Japan	Axjj~	Axju~	Axja~	Fdjj~	Fdju~	Fdja~	Ejr~	Xj~
	The United States	Axuj~	Axuu~	Axua~	Fduj~	Fduu~	Fdua~	Eur~	Xu~
	Asia	Axaj~	Axau~	Axaa~	Fdaj~	Fdau~	Fdaa~	Ear~	Xa~
Import	ROW	Axrj~	Axru~	Axra~	Fdrj~	Fdru~	Fdra~		
Value added		Vj~	Vu~	Va~					
Production		Xj~	Xu~	Xa~					

Asian international input output table(overseas subsidiary)		Intermediate demand: Japan	Intermediate demand: The United States	Intermediate demand: Asia	Final demand: Japan	Final demand: The United States	Final demand: Asia	Export: ROW	Production
Intermediate Input	Japan	–	Axju*	Axja*	–	–	–	–	–
	The United States	Axuj*	Axuu*	Axua*	Fduj*	Fduu*	Fdua*	Eur*	Xu*
	Asia	Axaj*	Axau*	Axaa*	Fdaj*	Fdau*	Fdaa*	Ear*	Xa*
Import	ROW	–	Axru*	Axra*	–	–	–		
Value added		–	Vu*	Va*					
Production		–	Xu*	Xa*					

(3) Integration of each activity into one input output table

Asian international input output table		Intermediate demand (non-overseas subsidiary): Japan	The United States	Asia	(overseas subsidiary): The United States	Asia	Final demand: Japan	The United States	Asia	Export: ROW	Production
Intermediate input (non-	Japan	Axjj~	Axju~	Axja~	Axju*	Axja*	Fdjj~	Fdju~	Fdja~	Ejr~	Xj~
	The United States	Axuj~	Axuu~	Axua~			Fduj~	Fduu~	Fdua~	Eur~	Xu~
	Asia	Axaj~	Axau~	Axaa~			Fdaj~	Fdau~	Fdaa~	Ear~	Xa~
(overseas subsidiary)	The United States	Axuj*			Axuu*	Axua*	Fduj*	Fduu*	Fdua*	Eur*	Xu*
	Asia	Axaj*			Axau*	Axaa*	Fdaj*	Fdau*	Fdaa*	Ear*	Xa*
Import	ROW	Axrj~	Axru~	Axra~	Axru*	Axra*	Fdrj~	Fdru~	Fdra~		
Value added		Vj~	Vu~	Va~	Vu*	Va*					
Production		Xj~	Xu~	Xa~	Xu*	Xa*					

(4) input output table, recompiled

Asian international input output table		Intermediate demand (non-overseas subsidiary): Japan	The United States	Asia	(overseas subsidiary): The United States	Asia	Final demand: Japan	The United States	Asia	Export: ROW	Production
Intermediate input (non-	Japan	Axjj~	Axju~	Axja~	Axju*	Axja*	Fdjj~	Fdju~	Fdja~	Ejr~	Xj~
	The United States	Axuj~	Axuu~1	Axua~1	Axuu*1	Axua*1	Fduj~	Fduu~	Fdua~	Eur~	Xu~
	Asia	Axaj~	Axau~1	Axaa~1	Axau*1	Axaa*1	Fdaj~	Fdau~	Fdaa~	Ear~	Xa~
(overseas subsidiary)	The United States	Axuj*	Axuu~2	Axua~2	Axuu*2	Axua*2	Fduj*	Fduu*	Fdua*	Eur*	Xu*
	Asia	Axaj*	Axau~2	Axaa~2	Axau*2	Axaa*2	Fdaj*	Fdau*	Fdaa*	Ear*	Xa*
Import	ROW	Axrj~	Axru~	Axra~	Axru*	Axra*	Fdrj~	Fdru~	Fdra~		
Value added		Vj~	Vu~	Va~	Vu*	Va*					
Production		Xj~	Xu~	Xa~	Xu*	Xa*					

Import of intermediate goods from Japan is contained. (Export induced effect)

Export of Intermediate goods from Japan (Export induced effect)

Export of final goods to Japan (Effect of reimport)

Purchaging of intermediate goods in the local markets

Export of intermediate goods to Japan (Effect of reimport)

Substitutes the export of Japan, partly (Export substitution effect)

First of all, we compile the original input-output table to obtain a 20-sector 3-region table as stated above. Then we estimate the activities of Japanese overseas affiliates in 20 sectors of the US and Asia economies: production, intermediate demand, final demand and export demand. Subtracting these overseas activities from the original values in the table, we obtain the activities of firms that have no relationship with Japanese firms in terms of ownership.

To estimate activities of Japanese firms overseas, we make use of METI statistics regarding the overseas activities of Japanese firms. Assuming that the value of sales is equal to the value of production, we can estimate the value of goods produced by Japanese firms overseas by sector and by region.[3] Dividing the value of purchases from each region by the estimated value of production, we can derive intermediate input ratios, which are used to assign an input value for each region to each sector. In addition, the sales ratio for each region is used to assign the demand by region to each sector. In this way we can roughly assign the inputs and demands by region and by sector for the overseas activities of Japanese firms. The detailed input coefficients are estimated by applying the relative values of the input coefficients of the original input-output table.[4] Final demand is estimated to fill the identity so that total supply equals total demand in each sector.

Secondly, we integrate the extracted activities of Japanese overseas production to create a single input-output table. In this stage, the domestic input of Japanese overseas activities in the US includes both that of Japanese overseas firms and that of non-Japanese firms in the US. The situation is the same for the structure of non-Japanese firms in the US. Consequently, we have to separate these inputs not only for the US but also for Asia. To do this, we need information about the degree to which Japanese firms overseas purchase intermediate goods and services from Japanese firms in the local market and the degree to which they sell intermediate goods and services to non-Japanese firms in the same market. Unfortunately, such information cannot be obtained systematically. In this paper, we divide them up according to their production shares, assuming that purchases depend on the production ability of suppliers.[5]

The recompiled input-output table shows many aspects relating to the activities of Japanese firms overseas. Their intermediate inputs and final demand from Japan are considered in terms of the induced export demand effect for Japan. The table includes exports of intermediate and finished goods and services to Japan, which is described as the re-import effect of Japan. However, in order to measure the export substitution effect, we need additional information regarding the degree to which the final demand of Japan is affected by production at overseas affiliates.

Table 2 is the estimated input-output table, which is aggregated to one sector for each region. From this table, we can find that production by Japanese firms in the US is worth $211.34 billion, which is larger than the $158.62 billion produced by Japanese firms in Asia. Japanese firms sell a great deal of intermediate and finished goods to the local market in both the US and Asia. However, there are some differences between the two markets. In the US market, Japanese firms sell more finished goods than intermediate goods, while the opposite is true in the Asian market. Japan imports more goods and services from Japanese affiliates in Asia than it does from those in the US. The local content ratio of firms in the US seems larger than that of firms in Asia as a whole.

Table 2 Recompiled Input-Output Table

Unit: $1 billion

	Intermediate demand					Final demand				Production
	Japan	United States	Asia	United States, Japan	Asia, Japan	Japan	United States	Asia	Other	
Japan	4283.03	31.06	77.07	24.12	26.40	4967.46	65.30	55.01	216.48	9745.93
United States	38.90	5722.33	61.24	71.96	0.94	24.74	6711.06	33.48	580.48	13245.14
Asia	48.45	63.32	2192.48	2.89	47.91	29.00	63.70	1859.97	400.46	4708.18
United States, Japan	4.02	95.12	1.65	2.67	0.03	2.37	103.05	0.87	1.57	211.34
Asia, Japan	13.66	2.40	65.96	0.13	3.00	11.72	2.33	54.55	4.87	158.62
Other	192.80	360.07	273.57	2.09	6.75	87.39	272.74	147.88	0.00	0.00
Value added	5165.07	6970.85	2036.21	107.48	73.59	0.00	0.00	0.00	0.00	0.00
Production	9745.93	13245.14	4708.18	211.34	158.62	5122.68	7218.19	2151.75	1203.86	28069.21

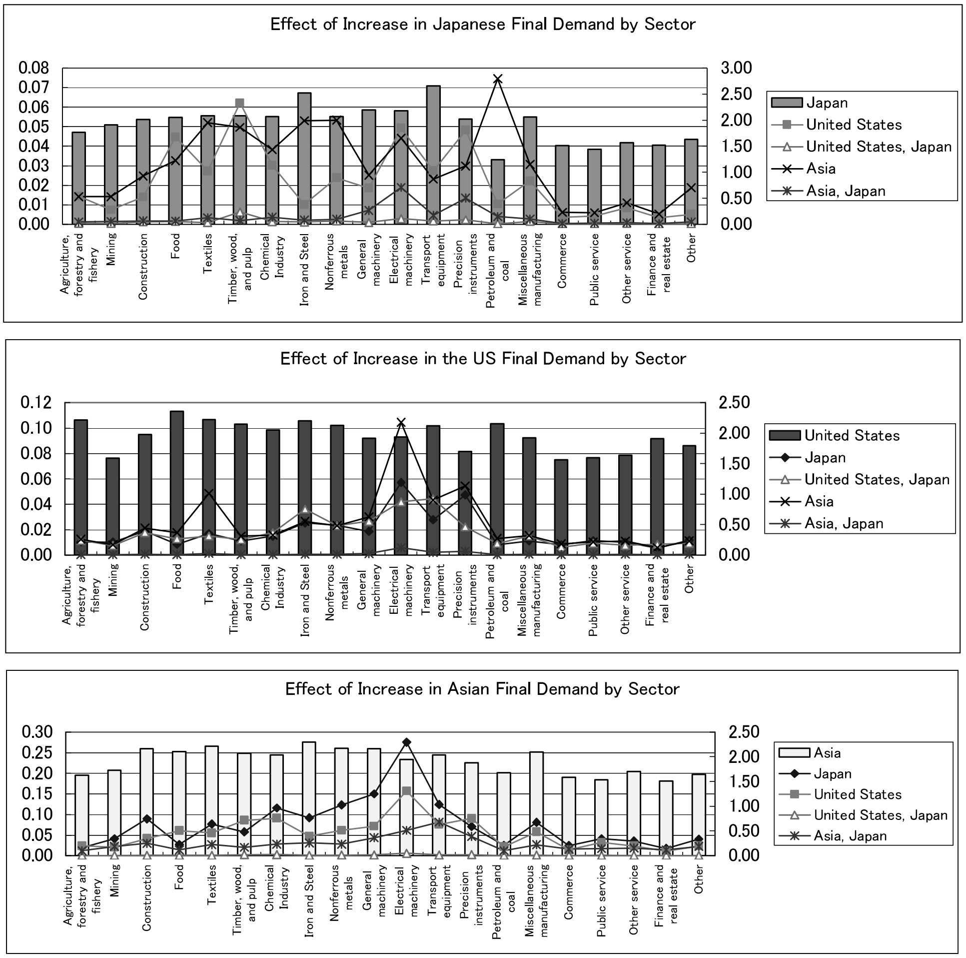
4. Some simulation results

In this section, we discuss some results of simulations. The first one is intended to evaluate international links using induced production stemming from one unit increase in final demand by sector and region. Secondly, we outline the regional contribution of Japanese overseas production through the induced value added in each region. Finally, we discuss the overall effect of Japanese overseas production on Japan, comparing its induced demand and substitution effects.

4.1 The induced production of one unit increase in final demand

Figure 2 shows the degree to which production is induced by one unit increase in final demand by sector and region. The effect on production is the largest in the home market for each sector. Here we mainly examine international interdependence. A unit increase in most manufacturing sectors in Japan has a significant effect on both the US and Asian economies. However, some differences are observed. Final demand increases in food, timber, wood and pulp, and electrical machinery in Japan have a great effect on the US economy. For the Asian economy, the effects of petroleum and coal are the largest, followed by those of textiles, timber, wood and pulp, iron and steel, non-metal products, and electrical machinery.

Figure 2 Induced Production Stemming From a Unit Increase of Final Demand for Each Sector and Country



Note: The own effect, shown as a bar, is measured on the right-hand axis, while the others, shown as lines, are measured on the left-hand axis.

In the US case, the increase in final demand for electrical machinery in the US has the greatest effect on the Asian economy, followed by transport equipment, precision instruments and textiles. In addition, increases in the final demand for general machinery, electrical machinery, transport equipment, and precision instruments have a significant effect on Japan. This situation arises due to the fact that exports from Japan to the US are concentrated in the machinery sectors, because induced demand is transferred through international trade. The textile sector also has an influence over the Asian economy.

The relationship between the US and Japanese firms in the US economy is very similar to that between the US and the Japanese economy, in both size and direction, which is very interesting. The leading export sectors in Japan, such as electrical machinery and transport equipment, have expanded into the US market through FDI. However, the relationship with Japanese overseas firms in Asia seems very weak.

In the case of Asia, the increase of final demand in the electrical machinery sector has the highest effect on Japan, while the effects of general machinery, transport equipment are also considerable. The increase of final demand in Asia's machinery sectors has a relatively large impact on the US economy, but this is not so great as the effect on Japan. Asian production is connected to Japan more than to the US, especially in the machinery sectors. An increase in Asian demand has an impact on Japan overseas affiliates in Asia to some extent, though the effect on Japanese overseas affiliates in the US is almost negligible.

4.2 Contribution in terms of the induced value added

The sum of the increases in import demand and value added, which are induced by a unit increase in final demand, is known to be same as the value of the initial increase in final demand (see Matsumura & Fujikawa (1998)). From this relationship, we can evaluate regional contributions to unit production of final demand in terms of value added and imports. Here we are able to determine who benefits from this. Figure 3 shows regional contributions to the production of finished goods by Japanese overseas affiliates in the US and Asia, respectively.

With regard to production by Japanese overseas firms in the US, the contribution of own value added is obviously the highest in almost all sectors. In this case, "own" denotes Japanese overseas firms. Accordingly, we will focus on the contributions of the others in Figure 3. We find that the US contributions are dominant. Japan makes a relatively significant contribution in the following sectors: general machinery, electrical machinery, precision instruments, petroleum and coal, and miscellaneous manufacturing. Most of these sectors are export-intensive sectors in Japan. The Asian contribution is almost negligible, but slightly more significant in the case of electrical machinery and miscellaneous manufacturing. The contribution of Japanese overseas firms in Asia is also negligible.

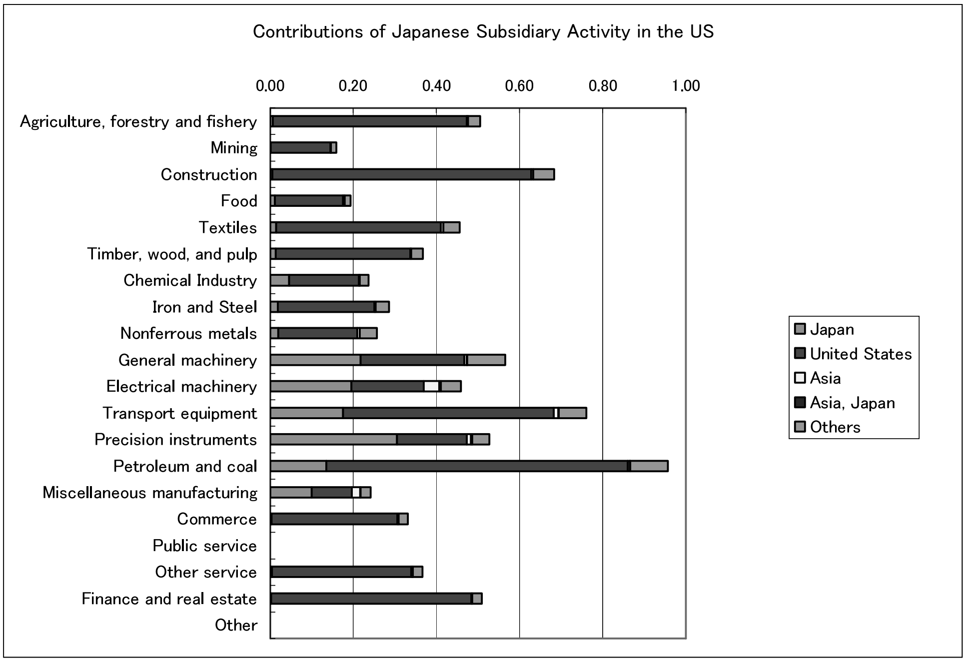
In the case of Japanese overseas production in Asia, the contribution of the local economy in Asia is also the largest except in terms of the own contribution. Japan's contribution is almost as much as that of the local economy in the case of the machinery, textile, chemical industry, iron and steel, and non-metal industry sectors. The contribution of the US is not so high, and that of Japanese overseas firms in the US is negligible.

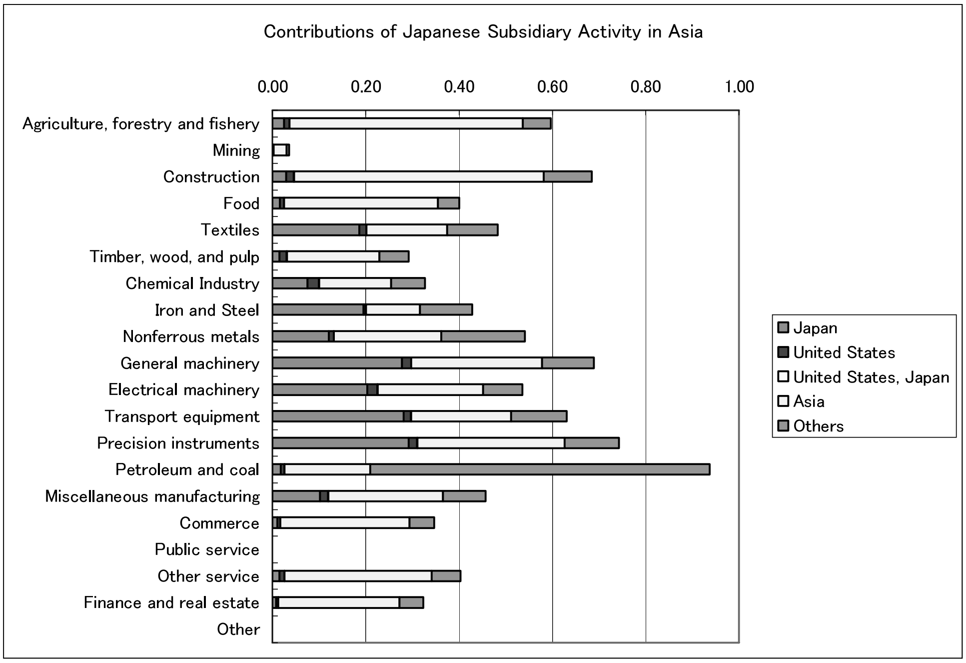
Japan has different patterns in terms of its contributions to overseas firms by sector in the US and Asia. A relatively high contribution is observed in the case of the machinery sectors in the US, though its contribution to overseas firms in Asia is not insignificant in such sectors as textiles, chemical industry, iron and steel, non-ferrous metals and machinery. The relationship between Japanese overseas activities in the US and in Asia seems to be negligible.

4.3 The induced production effect versus the substitution effect of overseas production

Finally, we discuss the induced production and substitution effects that Japan

Figure 3 Value Added by Region





incurs due to Japanese overseas production. How much production in Japan is induced by the overseas production of Japanese firms? How much production is substituted by this overseas production? [6]

Table 3 shows the results of a simulation. In Case 1, the induced production of Japanese overseas production is calculated. The production of finished goods by Japanese overseas firms in the US totals $108.99 billion, which increases Japanese production by $30.07 billion and US production by $78.75 billion. Total induced production is $224.53 billion. On the other hand, production by overseas firms in Asia is $73.18 billion, which increases Japanese production by $31.20 billion and US production by $46.51 billion, to give total induced production of $156.12 billion. Although production by overseas firms in Asia is about 70% of the US level, the induced production effects in Japan are almost the same in both cases.

Production by Japanese overseas firms substitutes for Japanese final domestic demand and exports to some extent. What value can be placed on this substitution? If we assume that overseas production substitutes for Japanese final demand completely, the reduction would be $76.74 billion in the US case and $61.29 billion in the Asian case, as shown in Case 2.[7]

In Case 2, we find that Japanese final demand is substituted by $76.74 billion, while Japanese production is reduced by $183.60 billion with regard to overseas production in the US and by $140.04 billion in the case of overseas production in Asia. The reductions in production are dominant only in Japan.

It may, however, be unrealistic to assume full substitution, so our alternative assumption is that final demand is substituted by the same proportion as the share of Japanese exports among total world exports in each sector; this constitutes Case 3. The export shares are shown in the first column of Table 4. The average shares are 13.18% in the US case, and 12.75% in the Asian case. We therefore express these cases as $\alpha=0.13$ in Tables 3 and 4. As a result, Japanese domestic production is reduced by $24.77 billion and $18.27 billion respectively.

Comparing these values, we can gain a picture of the overall effects for the different degrees of substitution. Case 4 shows the overall effect, assuming that overseas production completely substitutes for Japanese final demand. However, if the substitution is more moderate, this might be an overestimate. Then we assume that the substitution is about 13% of average[8] overseas production, as shown in Case 5. In this case, the induced production effect overcomes the substitution effect in Japan as a whole. Japanese domestic production increases by $5.29 billion due to overseas production in the US, causing own production to reach $111.38 billion. Of course, the US economy gains mainly in terms of production, while the Asian economy experiences only small gains. On the other hand, overseas production in Asia worth $75.31 billion causes an increase in Japanese production of $12.92 billion. The increase in Japanese production in the Asian case is more than twice that seen in the US case, although the value of Japanese overseas production in the US case is actually larger than in the Asian case.

Table 4 shows the effect on Japanese production by sector in Cases 4 and 5. As has already been demonstrated, the overall effects on Japanese production are positive in Case 5. However, we find that production of transport equipment brings

Table 3 The Effect of the Japanese Overseas Production

Unit: $1 billion

	Case 1		Case 2		Case 3		Case 4		Case 5	
	Induced production effect		Substitution effect		Substitution effect		Induced production and substitution effect		Induced production and substitution effect	
Changes in Final Demand	Japanese Subsidiary in U.S.	Japanese Subsidiary in Asia	Japanese Subsidiary in U.S. $\alpha=1$	Japanese Subsidiary in Asia $\alpha=1$	Japanese Subsidiary in U.S. $\alpha=0.13$	Japanese Subsidiary in Asia $\alpha=0.13$	Japanese Subsidiary in U.S. $\alpha=1$	Japanese Subsidiary in Asia $\alpha=1$	Japanese Subsidiary in U.S. $\alpha=0.13$	Japanese Subsidiary in Asia $\alpha=0.13$
Japan	0.00	0.00	-76.74	-61.29	-10.11	-7.81	-76.74	-61.29	-10.11	-7.81
United States	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
United States, Japan	108.99	0.00	0.00	0.00	0.00	0.00	108.99	0.00	108.99	0.00
Asia, Japan	0.00	73.18	0.00	0.00	0.00	0.00	0.00	73.18	0.00	73.18
Total	108.99	73.18	-76.74	-61.29	-10.11	-7.81	32.25	11.89	98.88	65.36
Induced Production										
Japan	30.07	31.20	-183.60	-140.04	-24.77	-18.27	-153.53	-108.85	5.29	12.92
United States	78.75	2.69	-2.54	-2.23	-0.34	-0.30	76.22	0.45	78.41	2.38
Asia	3.99	46.51	-2.34	-2.13	-0.30	-0.27	1.65	44.38	3.69	46.24
United States, Japan	111.40	0.09	-0.15	-0.13	-0.02	-0.02	111.25	-0.04	111.38	0.07
Asia, Japan	0.32	75.63	-0.61	-0.64	-0.09	-0.10	-0.30	75.00	0.22	75.54
Total	224.53	156.12	-189.24	-145.18	-25.53	-18.96	35.29	10.94	199.00	137.16
Induced Production(%)										
Japan	27.59	42.63	-168.46	-191.38	-22.73	-24.97	-140.87	-148.74	4.86	17.66
The United States	72.26	3.67	-2.33	-3.05	-0.31	-0.41	69.93	0.62	71.95	3.26
Asia	3.66	63.56	-2.15	-2.92	-0.28	-0.37	1.51	60.65	3.38	63.19
United States, Japan	102.22	0.12	-0.14	-0.18	-0.02	-0.02	102.08	-0.06	102.20	0.10
Asia, Japan	0.29	103.36	-0.56	-0.87	-0.08	-0.13	-0.27	102.49	0.21	103.22
Total	206.01	213.34	-173.64	-198.39	-23.42	-25.91	32.38	14.95	182.59	187.43

* The value of the final demand in Case 1 is not equal to the sum of the corresponding final demand in Table 2, because a statistical discrepancy in Table 2 is excluded here.

about a reduction of $4.16 billion in the US case, but electrical machinery production gives rise to an increase of $4.13 billion. Japanese automobile companies began investing in the US market in 1990s, leading to a reduction in automobile exports from Japan. We also find negative effects on the production of precision instruments. We can therefore conclude that the induced production effect overcomes the substitution effect in Japan as a whole. However, the hollowing-out of production may be apparent in such sectors as transport equipment and precision instruments.[9]

Table 4 The Effect of Japanese Overseas Production on Japan

Unit: $1 billion

	Sectors	Japanese Export Ratio to the World Total	Case-4		Case-5	
			Induced production and Substitution Effect on Japan		Induced production and Substitution Effect on Japan	
		(%)	Japanese subsidiary in U.S. α =1	Japanese subsidiary in Asia α =1	Japanese subsidiary in U.S. α =0.13	Japanese subsidiary in Asia α =0.13
1	Agriculture, forestry and fishery	0.52	-1.36	-1.07	0.02	0.03
2	Mining	0.27	-0.45	-0.17	0.01	0.02
3	Construction	0.00	-2.28	-3.65	0.05	0.10
4	Food	0.57	-5.56	-3.72	0.01	0.05
5	Textiles	2.22	-1.08	-3.49	0.07	0.33
6	Timber, wood, and pulp	0.50	-2.40	-1.49	0.13	0.20
7	Chemical Industry	6.05	-6.69	-3.00	0.29	1.17
8	Iron and Steel	11.26	-5.95	-2.09	0.65	2.42
9	Nonferrous metals	5.23	-3.59	-3.08	0.73	0.89
10	General machinery	14.65	-6.87	-3.61	0.41	0.79
11	Electrical machinery	15.87	-21.04	-28.25	4.13	1.94
12	Transport equipment	15.34	-58.77	-26.18	-4.16	0.34
13	Precision instruments	17.11	-0.91	-2.30	-0.02	-0.06
14	Petroleum and coal	1.94	-0.92	-0.75	0.06	0.17
15	Miscellaneous manufacturing	4.73	-9.81	-7.07	0.49	0.74
16	Commerce	0.00	-6.63	-4.73	1.17	1.57
17	Public service	0.00	-0.37	-0.27	0.02	0.03
18	Other service	0.00	-8.48	-6.54	0.50	0.83
19	Finance and real estate	0.00	-3.02	-2.21	0.18	0.34
20	Other	0.00	-7.34	-5.19	0.57	1.00
	Average for U.S.	13.18	-	-	-	-
	Average for Asia	12.75	-	-	-	-
Total		-	-153.53	-108.85	5.29	12.92

5. Concluding remarks

In this paper, we recompile the IDE Asian international input-output table for 1995 to deal explicitly with Japanese overseas production activities and to analyze the relationship between Japanese overseas activities and the economies of the home and invested countries. For this purpose, we make use of METI survey statistics on the overseas activities of Japanese firms in the same year. The recompiled input-output table shows the interdependence among them, allowing us to clarify the role of Japanese overseas firms.

Japanese overseas production in the US is about 2.17% of production of Japan, while that in Asia is 1.63%. Japanese purchases of intermediate and finished goods from subsidiaries in Asia amount to 16.00% of Japanese subsidiaries' production in Asia, whereas purchases from subsidiaries in the US total just 3.02%. On the other hand, the purchase of intermediate goods from Japan is 11.41% of overseas production in the US and 16.64% in Asia. These show that Japanese subsidiaries in Asia have a stronger link to the Japanese economy than do those in the US.

Moreover, looking at the effect on production of increased final demand, the relationship between Japan and Japanese subsidiaries in Asia demonstrates a close interdependence in the case of machinery sectors. In addition, Japanese subsidiaries in the US are affected strongly in the case of US machinery sectors, which is similar to the effect on Japanese production. This reflects the fact that overseas production in the US is concentrated in the machinery sectors, where Japan has export competitiveness.

The simulation of the contribution in terms of value added shows that overseas production is connected, to a considerable extent, to each local economy, i.e. that of the US and Asia. Overseas production affects the home country in two different ways: the induced production effect and the substitution effect. The overall effect on home production depends on the degree of substitution. If the degree of substitution is the same as the share of Japanese exports in total world exports for each sector, then the two different effects on home production would cancel each other out. However, hollowing-out in production might occur in such sectors as transport equipment and precision instruments. Of course, these are tentative results. We need more evidence, especially with regard to the degree of the substitution of overseas production.

Issues to be settled when we apply the METI survey to the input-output table include the definition of terms, whether the fiscal or calendar year is used, the definition of sectors, data coverage problems attributable to survey statistics and the definition of Japanese affiliates. In spite of these outstanding issues, our analytical framework provides a new way of investigating the relationship between the home and invested economies arising from overseas production. Furthermore, China is such an important economy as to warrant its being dealt with separately from Asia. The relationship between Japan and Europe is also significant. These issues should be considered in our future research.

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Notes

[1] There may be some differences between Southeast Asian countries and China in considering Japanese overseas production activities. However, we treat them as one region, mainly because of the limited availability of data.

[2] These figures are recognized to vary considerably year by year, because they are dependent on sampling data as opposed to estimated values for the population. Fukao *et al*. (1999) tried to estimate population values for these statistics. However, we use the values reported in these statistics with no correction, because we have no appropriate information for correcting it.

[3] The sales value is not equal to the production value in terms of inventory changes. However, we treat them the same, assuming there are no changes in the inventory.

[4] Though we use the input coefficients of the original input-output table to estimate the detailed input coefficients of Japanese overseas production, the input structure of Japanese overseas production is not the same as that of the rest of the region. This is simply because of the difference in trade patterns for both activities.

[5] Because this division of intermediate demand violates the demand-supply relationship, we have modified final demand to compensate for this.

[6] R.E. Lipsey and E.D. Ramstetter (2001) and E.D. Ramstetter (2002) investigated the relationship between affiliate activity in Japan, U.S. multinationals and Japanese exports, concluding that there were no significant negative relationships.

[7] These values are smaller than those of Case 1, because the substitution would be limited to tradable goods.

[8] We express these cases as α =0.13 in Tables 3 and 4, because the average export ratio is about 13% in both cases. However, export substitution depends on the different export ratios by sector as stated in Table 4.

[9] This conclusion is heavily dependent on the assumption of substitution. If the substitution ratio is higher than our assumption, the overall effect on Japanese production might be negative, as shown in Case 4, which is an extreme case.

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Regional Aspects of Economic Growth in Russia

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Abstract

The economic growth observed in Russia since 1999 has been unevenly spread within the country. The level of decline in production during the transition recession differed in various regions, as well as the pace of economic recovery and growth. As a result, some regions became leaders in economic growth, while others became outsiders, thereby enhancing the disparity between the regions and exacerbating problems in political relations between the federal centre and the regions. This paper provides statistical data that describes the difference in economic growth rates between the Russian regions and changes in the geographical distribution of the employed population as well as the spatial allocation of economic activities. We provide statistical estimates of the results and factors defining the regional features of economic growth in Russia during the period 1999-2002 on the basis of panel data for 79 regions.

KEYWORDS: *economic growth, Russian regions, regression analysis, panel data*

1. Introduction

The economic reforms undertaken in Russia at the beginning of the 1990s varied significantly in regional perspective in terms of the methods used and the results achieved. The vast territory of the Russian Federation consists of a large number of regions with different climatic conditions, as well as varying levels of economic development and standards of living. The level of decline in industrial production differed between regions, as did the pace of the formation and development of market sectors. The economic reforms have, *inter alia*, changed the geographic distribution of the population as well as the allocation of economic activities between regions.

The economic growth observed in Russia since 1999 is also unevenly spread within the country. As a result, some regions have become leaders in economic growth, while others became outsiders, thereby creating a gap in the level of economic development and standards of living, enhancing disparities between regions and exacerbating problems in political relations between the federal centre and the regions.

The problems associated with economic growth in Russia have been widely discussed in a variety of academic literature. The issues being discussed are the factors and sources of economic growth, characteristics of economic growth and evaluations of the perspectives of economic growth in different sectors of the economy. Probably the most major issue discussed in Russian and foreign academic literature in relation to regional development is that of federal budgeting. In considering the significance of inter-budget relationships, deep research into the

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factors and conditions influencing economic growth in various regions is often omitted despite the fact that the differences in the economic development of the regions and inter-regional disparities arising as a result of such differences form the economic basis of budgeting problems. This paper provides statistical estimates of the results and factors influencing the economic growth of the Russian economy in the period 1999-2002.

2. Statistical evidence

Spatial analysis of the Russian economy is traditionally carried out for individual administrative regions of the Russian Federation. The borders of such regions have been established in most cases based on non-economic factors, therefore they differ significantly in terms of the size of their populations, the area that they cover, their economic potential, production level and industrial production structure, standards of living and other factors[1]. Should the federal districts be taken as the basis for analysis rather than the federal administrative regions, inter-regional differences may be reduced to some extent, but they cannot be eliminated entirely.

Significant differences between various regions existed prior to the economic reforms, however the reforms have led to further disparities in economic and social development that can be observed in virtually all the statistical indicators. When the state regulation of the national economy, including the inter-regional proportions of production and consumption, was abandoned under the economic reforms, the economic and social development of individual regions became affected by a variety of new factors. Such factors included, *inter alia*, the tempo and pace of economic transformation, market development, resource potential and the geographical location of the regions (particularly the ability of the regions to participate in international trade), relations with the federal authorities and the ability of the regional authorities to adapt to the new economic situation and benefit from it. One of the results of economic reforms in Russia from the regional perspective was the aggravation of the heterogeneity of economic territories and the subsequent growth in the economic, social and political problems associated with inter-regional disparity.

Economic growth can either reduce or escalate inter-regional disparity. Ideally, if economic growth were more intensive in those regions that have borne the brunt of suffering arising from the reforms, such growth would reduce the differences between the regions, leading to convergence in the level of economic development of the "stronger" and the "weaker" regions and thus automatically resolving the problem of inter-regional disparity. However, such a situation is unlikely. It is much more likely that economic growth will take place in the most effective, "stronger" regions, further adding to their advantages and exacerbating inter-regional problems. In the case of significant polarization in growth rates as considered by A. Granberg (Granberg, Zaitseva, 2002, p. 5), there are no grounds for talking about "the growth of the national economy as an integrated organism, about the development of social market"; the problems of an increase in disparities in the level of economic development in Russian regions, as well as the aggravation of the heterogeneity of economic territories during economic growth may be exacerbated even further.

Russia's GDP growth rate in relation to the previous year was 5.4% in 1999, 9.0% in 2000, 5.0% in 2001 and 4.3% in 2002. Average growth rates are based on the growth rates of individual regions, which may vary significantly (Table 1); thus, even though the average annual industrial production growth rate in the Russian Federation in 2000-2002 was 6.8%, the rate differs between major Russian regions (federal districts of the Russian Federation), ranging from 13.8% in North-Western district to 1.9% in the Far Eastern district. It should also be noted that the Far Eastern district only experienced economic growth in 2000.

Table 1 Average annual growth rates of major economic indicators in the federal districts of the Russian Federation in 1999-2002

(%)

Federal district	Gross regional product[2]*	Industrial production*	Agricultural production***	Retail trade turnover***	Investment in fixed capital*	Money income of population****
Russian Federation	7.0	6.8	5.4	5.3	10.2	8.6
Central	9.3	10.9	3.4	0.3	4.3	8.5
North-Western	6.7	13.8	4.3	4.2	14.7	8.4
Southern	9.4	10.6	10.1	7.2	21.8	11.4
Privolzhsky	5.4	6.0	4.9	1.9	9.9	11.0
Urals	6.2	7.4	3.7	5.5	26.1	11.7
Siberian	5.2	6.6	5.1	5.3	9.9	12.0
Far Eastern	3.1	1.9	1.6	4.4	23.0	11.2

*Average annual growth rates in1999-2001. ** Average annual growth rates in 2000-2002.
*** Average annual growth rates in1999-2002. **** Average annual growth rates in 2001-2002.
Source: calculated on the basis of Table A1.

Intensive economic growth is actually concentrated in a few regions; growth rates are low in the rest, with stagnation and a decline in production being experienced in some. The most favourable in the discussed four-year period, in terms of inter-regional disparities in economic growth, was 2000, when the high average growth rate of 9% of GDP was the result of the growth of the gross regional production rate in all but three administrative regions of the Russian Federation (Primorsky Krai, Mariy Al Republic and Sakhalin oblast). Industrial production growth took place in all regions except for Aginsky-Buryatsky Autonomous Okrug. In 2001, despite overall GDP growth in Russia, gross regional product[3]declined on the previous year in 11 administrative regions of the Russian Federation, while industrial growth was negative in 9 of them; in 2002, industrial production declined in 20 administrative regions of the Russian Federation, i.e. in each fourth region.

The greatest increase in the physical volume of GRP in general over the period 1999-2002 took place in the Central (30.5%) and Southern (30.8%) federal districts; looking at the situation by administrative region, the greatest increases were in Kalmykia (73.3%), Kabardino-Balkaria (47.1%), Astrakhan oblast (40.9%) and Rostov oblast (30.5%). The average annual GRP growth rate in Russia (5.7%) was exceeded by regional growth rates in 25% of regions, while in all the rest regional growth rates appeared to be lower than the average Russian rate.

The data exhibited in Table 1 do not provide for a direct relationship between the GRP growth rate and the growth rate of investments. The regions leading in terms of the growth rate of investments, where the annual investment growth rate exceeded 20%, include the Urals, Far Eastern and Southern federal districts. However, only in the Southern federal district did the GRP growth rate exceed the average Russian rate, and the Far-Eastern federal district demonstrated the lowest GRP growth rate of all the federal districts, having an annual investment growth rate of 23%. In contrast, the Central federal district simultaneously had the highest GRP growth rate and the lowest investment growth rate. Therefore, from an analysis of the statistical data by federal district it appears that economic growth is predominantly based on regional resources.

Table 2 The share of budget investment in total investment in fixed capital

(%)

Federal district	Budgetary funds total			From federal budgetary funds			From budgetary funds of RF administrative regions		
	1999	2000	2001	1999	2000	2001	1999	2000	2001
Russian Federation	17.0	22.0	19.8	6.4	6.0	5.8	9.6	14.3	12.6
Central	18.4	37.0	30.6	7.9	7.6	6.9	10.3	28.6	23.3
North-Western	14.3	15.5	15.7	5.6	5.5	9.3	7.7	7.4	5.8
Southern	17.3	14.3	11.8	11.8	9.3	6.8	4.8	4.1	4.6
Privolzhsky	14.8	18.5	19.3	3.8	3.6	5.3	9.5	12.7	12.6
Urals	17.8	16.4	16.4	2.5	2.4	1.6	12.8	11.2	11.2
Siberian	17.4	17.6	16.9	8.3	9.1	6.7	8.4	7.3	9.0
Far Eastern	18.8	21.4	18.4	9.5	10.2	9.8	9.2	10.8	8.4

Source: (Goskomstat…, 2002, pp. 806-807).

The relationship between the growth rate and investment covered by the budget (Table 2) appears to be more transparent. The Central federal district is top in terms of the share of investment covered by the budget in the total amount of investment, and it also demonstrated the highest growth rate. The high growth rates in the North-Western and Southern federal districts are determined mostly by own and debt non-budget financing sources.

As a result of uneven inter-regional dynamics in the Russian economy during the 1990s, the regional distribution of economic activity has changed. We have carried out an evaluation of trends in the dynamics of the inter-regional industrial production structure in the Russian Federation during the transformational recession (Prostranstvennye … , 2002) on the basis of three statistical indicators[4] the shares of economic regions[5] in GRP calculated in fixed prices, the shares of economic regions in GRP in current prices and the shares of economic regions in total employed population. Even though these indicators have substantial differences, the evaluations of the changes that took place in the regional production structure in the 1990s are similar. Statistical analysis demonstrates a tendency towards movement in the production structure from north-eastern regions to south-western regions, when economic activities are decelerated in the underpopulated eastern and northern regions and shifted to the most developed and highly populated regions. These tendencies determine the changes in inter-regional proportions that arise as a result of the transformation to a market economy. This also raises a question about the direction of the movements in the regional structure that are currently being observed during the period of economic growth. Although the growth period is very short, it still allows the possibility of identifying some of its specific features.

The regional structure of the allocation of employed population and fixed economic assets (only data on the regional structure of these indicators and the GRP for the years 1999-2001 were available to us) has hardly changed over the three-year growth period. By 2001, the share of the Southern federal district had increased slightly, and there was a simultaneous decrease in the shares of other districts except for the Central and the Far Eastern federal districts (Table 3). With respect to the geographical allocation of fixed assets, the share of the Urals federal district increased considerably, accompanied by a simultaneous decrease in the shares of all districts other than that of the Far Eastern district. Thus, economic growth, unevenly distributed by region, has not been accompanied by changes in the regional structure of the production factors, and was mainly caused by varying growth in the effectiveness of the exploitation of such factors.

Table 3 Regional structure of indicators of economic development in the Russian Federation

(%)

	Employment		Fixed assets		GRP	
	1998	2001	1998	2001	1998	2001
Central	27.0	27.0	25.4	24.1	29.4	34.0
North-Western	10.4	10.3	10.4	9.7	10.3	9.6
Southern	12.6	12.9	10.4	9.8	8.1	7.8
Privolzhsky	22.1	22.1	20.4	20.0	19.2	17.5
Urals	9.1	9.0	12.8	17.8	14.0	15.0
Siberian	13.7	13.6	14.5	12.4	13.1	11.2
Far Eastern	5.1	5.1	6.1	6.2	6.0	4.8
Russian Federation	100.0	100.0	100.0	100.0	100.0	100.0
	Industrial production		Agricultural production		Dwelling construction	
	1998	2002	1998	2002	1998	2002
Central	25.1	27.3	24.0	22.3	32.4	35.8
North-Western	11.4	12.6	6.7	6.4	7.5	7.9
Southern	8.2	9.3	17.0	20.3	15.7	15.3
Privolzhsky	26.9	24.7	24.1	23.8	24.7	22.4
Urals	12.0	11.3	6.7	6.3	7.8	8.4
Siberian	11.0	10.4	17.2	17.1	9.3	8.0
Far Eastern	5.4	4.4	4.4	3.8	2.6	2.1
Russian Federation	100.0	100.0	100.0	100.0	100.0	100.0

Source: calculated on the basis of Goskomstat RF data

In the regional structure of GRP, the share of the Central federal district increased (by 4.6%) and the share of the Urals federal district rose by 1 per cent point, but the shares of all the other districts decreased.

The data on industrial production, production in agriculture and construction relate to 1999-2002 and therefore allow the evaluation of changes in the regional structure of production for a longer period[6].

Unlike the allocation structure of production factors, the regional production structure has changed considerably. The shares of the Far Eastern, Siberian and Privolzhsky federal districts in the structure of all of the above indicators has decreased significantly. The share of the Southern district in industrial and agricultural production has increased, while its share in construction has decreased slightly. There is also an evident tendency of growth in the shares of the Central and the North-Western districts in industrial production and construction, accompanied by a simultaneous decrease in the share of these districts in agricultural production. The trends in the Urals federal district are generally the same as in the eastern regions: its share in industrial and agricultural production has decreased, and only its share in construction has increased.

Thus, economic growth has not provided for changes in the tendency towards transformation in the regional structure of the Russian economy that existed in the recession period. Intensive economic growth in the European part of the country has resulted in a decline in the share of the eastern regions of the country in the economic structure. There was also a remarkable increase in the shares of the Central, the North-Western and the Southern districts in terms of most economic indicators, with a simultaneous decrease in the shares of the Far Eastern and Siberian districts.

The changes in the proportions of the largest regions, which are federal districts, are caused by growth in several leading administrative regions of the Russian Federation within those districts, as in each of the districts there are both effectively developing and ineffective, problem regions.

The tendency for production to be concentrated in several highly developed regions that was identified by A. Granberg and Yu. Zaitseva (Granberg, Zaitseva, 2002) still existed during the economic growth period. In 1998, seven mostly developed administrative regions of the Russian Federation accounted for 41% of the country's total GRP, while in 2001 this share was 47.6%; the share of the last ten percentile (8 RF regions) was 0.5% in 1998, a figure that hardly changed in 2001 (0.6%). The structure of the top and bottom ten percentiles has been stable (Table 4), with the bottom group experiencing only changes in the rankings of different regions. Samarskaya oblast has fallen out of the top group, to be replaced by the Republic of Tatarstan; the rank of Krasnoyarsky krai has increased remarkably, as a result of high growth rates over the last three years, pushing the region up into fourth place in terms of the volume of GRP and it has almost reached the level of the national leaders - the city of Moscow, Tyumen oblast and Moscow oblast.

Table 4 The structure of the top and bottom ten percentiles of regions of the Russian Federation by the volume of GRP[7]

1998	2001
Top 10 percentile (7 regions)	
Moscow City (CFD)	Moscow City (CFD)
Tyumen oblast (UFD)	Tyumen oblast (UFD)
Moscow oblast (UFD)	Moscow oblast (UFD)
St-Petersburg (NWFD)	Krasnoyarsky krai (SibFD)
Sverdlovskaya oblast (UFD)	St-Petersburg (NWFD)
Samarskaya oblast (PFD)	Republic of Tatarstan (PFD)
Krasnoyarsky krai (SibFD)	Sverdlovskaya oblast (UFD)
Bottom 10 percentile (8 regions)	
Republic of Adygeya (SFD)	Republic of Kalmykia (PFD)
Republic of Karachaevo-Cherkessia (SFD)	Republic of Ingushetia (SFD)
Chukotsky Autonomous Okrug (FEFD)	Republic of Adygeya (SFD)
Republic of Tyva (SFD)	Republic of Karachaevo-Cherkessia (SFD)
Republic of Kalmykia (PFD)	Jewish Autonomous oblast (FEFD)
Republic of Altay (SibFD)	Chukotsky Autonomous Okrug (FEFD)
Jewish Autonomous oblast (FEFD)	Republic of Altay (SibFD)
Republic of Ingushetia (SFD)	Republic of Tyva (SibFD)

Source: 1998 - calculated on the basis of Goskomstat RF data, 2001- (Granberg, Zaitseva, 2002, p.12)

The statistical data analysed above is evidence of the difference in the tempo of regional dynamics, arising during economic growth; however, it does not tell us whether the differences arose as a result of external regional development conditions, and to what extent they arose as a result of successful (or unsuccessful) market reforms, which, as has already been noted above, have been specific to each region.

3. Factors of economic growth

Each of the regions is developing within the national economy, therefore its development is determined by the factors and tendencies of national development. In the literature on the problems of economic growth in the Russian economy there are two major concepts that seek to explain the nature of economic growth. The first, and the most widespread concept argues that the economic growth is explained by the revaluation of the Russian rouble in terms of its real value after the crisis of 1998 and the increase in the competitive power of production, due to the favourable situation in the oil markets, as a result of the economic reforms carried out by the Russian government and the development of markets (Yasin, 2002; Sapir 2003, Uzyakov 2002, Pugachov, Pitelin, 2002).

The input of various factors to the economic dynamics was evaluated on the basis of a formal analysis of macroeconomic variables over the discussed period, carried out by the Institute of National Economic Forecasting of the Russian Academy of Sciences (Table 5). The major factors determining the economic growth of the Russian economy are the following: an increase in investment and consumption by households accompanied by a relatively stable export effect.

Table 5 Factors contributing to economic growth in 1999-2001

(%)

	1999	2000	2001
Growth rate	5.4	10.2	5.7
Growth factors			
Household consumption	-44.7	51.5	86.8
State consumption	11.5	3.1	-3.8
Investment	19.7	38.8	34.6
Increase in enterprise reserves	29.6	13.5	0.4
Exports	18.7	21.7	20.9
Imports	65.2	-28.6	-38.9
Total	100	100	100

Source: Uzyakov (2002, p. 4)

In accordance with the second concept (Mau, 2003; IET, 2003), it is considered that economic growth in Russia as well as in other countries with transitional economies represents economic restoration. The process of post-socialistic transformation involves the gradual re-allocation of resources from those activities that cannot be carried out in the market economy to those that are demanded in the markets. At the first stage, the released resources would generally exceed the amounts of resources necessary for the new enterprises, resulting in a recession. Later, the economy would pass breaking point, and the volumes of resources demanded by the new enterprises would exceed the resources released from ineffective branches of the economy. The specific features of the restoration of economic growth are its high rate and short duration, both of which were also present in the Russian economy in 1999-2002. This concept further gives special consideration to the role of institutional factors, as well as economic and political reforms.

Differences in economic growth rates in various regions are explained by the different reactions of regional economic systems to changes in the external environment (and the national economy represents an external environment to each particular region), by differences in the effectiveness of resource exploitation within different regions and by the pace of development of new enterprises that are effective in the market economy. Following the logic of the restoration of economic growth, the specific features of the transformation recession and the further recovery of economic growth in each region are determined by the same factors, however the extent of their influence on the economic growth indicators is different.

The regional aspects of the transformation recession in the Russian economy in the period 1992-1998, as well as in other countries with transitional economies, were previously discussed in a number of papers (Popov, 2000; Berkowits, DeJong 1998). Most of these research papers note the special impact on the economic transformation results of the initial conditions existing in each region before the economic reforms.

The recession was harsher in regions that had a high share of non-competitive enterprises in manufacturing industry. Conversely, the recession was milder in regions in which primary industry (including the fuel industry, energy, ferrous and non-ferrous metallurgy) was dominant, it being a sector characterized by lower labour productivity compared with manufacturing industry. Therefore it appears reasonable to infer that there is a close relationship between the regional export quota (the share of exports in GRP) and the production recession rate; the recession in the export-oriented regions was generally lower than the average Russian recession rate.

Research papers on regional dynamics in the transitional period also allocate a significant role to the pace and type of economic reforms (gradual reforming or "shock therapy") carried out in various regions (Popov, 1998). Thus, D. Berkowits and D. DeJong have found out that the variable determined by the type of region (i.e. the "red belt" region) was essential in explaining the reasons for the slow formation of new enterprises, while the relative size of the new enterprises has a positive relationship with the dynamics of the real income of the population (Berkowits, DeJong, 2000); however, the research does not draw any conclusions about the direct connection between the type of economic policy and reforms (liberal or pro-communist) carried out in the region and the recession rate.

An econometric analysis of the impact of institutional factors on the results of economic reforms in the Russian regions was carried out by V. Popov. The indicators used as determinants of the potential of regional institutions included the share of population employed in small enterprises, the investment risk index and the share of the shadow economy in the total income, production and employment of the region. A stable relationship between the effectiveness of the institutions (which has been measured by the share of state income and the share of the shadow economy in GRP) and the results of economic transformation has been identified: the more effective the institutions in the transitional period, the faster the recession was overcome (Popov, 1998).

Our evaluation of the impact of various factors on production dynamics in 1990-1996 for 76 Russian regions (Mikheeva, Differentiation ⋯, 1999; Mikheeva, Analiz ⋯, 1999) has allowed the statistical confirmation of the hypothesis that the rate of decline of regional economic indicators depends on their starting level. The factors depending on changes in the regional production structure and having considerable impact on regional dynamics (statistically significant in the regression equations) include, *inter alia*, the share of agriculture in GRP, which has a stabilizing effect on the dynamics, and the level of development of the service sector, which is inversely related to the recession rate, so that the higher the share of the service sector, the more significant were the differences in the recession tempo.

The evaluation of factors that are dependent on regional policy (per capita expenditure from the regional budget, inflation rate, per capita investment) have statistically confirmed the impact of such factors on regional disparities. The above factors have positive values in a regression equation, but their elasticity is low. This also confirms that the short- and medium-term regional economic policy measures, including, *inter alia*, the variables considered in the above analysis, have a limited effect on inter-regional differences.

Both the Barro specification (Barro, 1991; Barro, Sala-I-Martin, 1995) and the Levine and Renelt specification (Levine, Renelt, 1992), based on the extended Solow model, are widely used in western academic literature on the problems of dynamics and growth forecasting in transitional economies. The regression equation derived by Barro used the following factors as regressors: the initial level of income per capita, the share of government consumption in GRP and human capital characteristics, and the gross enrollment rates for primary and secondary school. Levine and Renelt have further included the growth rates of investment and population in the specification. The model has been further specified by Nauro (Nauro, 2001). We have tested this model using data for the Russian regions, but the results could hardly be considered to be positive[8].

4. The data for evaluation

The list of factors affecting inter-regional differences in economic dynamics considered in academic literature is vast and includes economic, social and political factors, as mentioned above. We have been limited in our choice of factors to be included in the research by the available statistical data. Regional statistics in Russia are significantly less comprehensive than national statistics, therefore the number of statistical indicators included in the research and their combination have been determined by the available statistical data outwith the substantial meaning of the factors.

The growth rate of gross regional product has been used as an overall result indicating regional dynamics. Average annual GRP growth rates in Russian regions are around 6.6%. In order to eliminate the impact of national growth tendencies on the regional growth rate we have excluded the national growth rate in each given year.

All the factors of economic growth have been divided into four groups, each including a set of statistical indicators that characterise the group:

1. Factors describing the initial level of development and the objective differences between regions;
2. Factors describing the specific features of the regional production structure;
3. Macroeconomic factors;
4. Economic policy and institutions.

The list of statistical indicators used in each group, as well as the parameters of the regression equations that describe the relations between the individual indicators and the overall indicator are given in Table A.2 of the annex.

The following facts have influenced our hypothesis in this research. The differences in regional production rates are largely determined by the initial level, which is used as a benchmark. The deeper the recession in a region, the higher the subsequent growth rate_this effect reasonably describes very high industry growth rates in a number of regions. As a benchmark for further evaluation of economic growth, we have used the industrial production recession level in 1998 compared with that in 1990 as a measurement of the recession level. Another indicator, describing the initial economic conditions, particularly the scale of economic activity in a region, is per capita regional GRP in 1998. We suppose there to be an inverse relation between the growth rate and the initial conditions in the region: the lower the level of economic development of the region in the initial period, the higher the subsequent growth rate should be.

The objective differences between the regions that determine regional development include factors relating to natural and geographical features. Such factors have been included in the analysis by using integrated indicators of objective differences between regions applied by the Ministry of Finance of the Russian Federation for the purposes of determining inter-budget transfers (Minfin, 2003) including the following: dispersal of population over the territory of the region, reflecting population density and distribution over the region; indicators of transport accessibility within the region, evaluated by transportation root density; and an indicator of the increase in governmental costs in the region, reflecting various characteristics relating to the regional differentiation of social costs, such as subsidies to municipal housing systems. It was further assumed that the higher population and transportation density have a positive impact on economic growth in the region, while the factors increasing governmental expenditure have a negative effect.

Production dynamics depend on the sectoral structure of the regional economy: recession in the industrial regions was higher than in the agricultural regions. Therefore we have assumed a predominant agricultural or predominant industrial structure of each regional economy as a factor in inter-regional disparities in the economic growth rates, each measured by the share of agriculture or industry in GRP.

Industry structure is also an important factor in differences in the regional economic growth rate. As mentioned above, the recession was lower in the regions where primary industry was predominant. However, the opportunities for intensive economic growth in primary industry are limited by external and internal demand for the raw materials produced. Conversely, recession was higher in the regions in which the manufacturing sector was predominant. The higher growth rates in manufacturing industries compared with primary industries represents a specific feature of industry growth in 1999-2001. An analysis of the changes in Russia's industrial structure (IET, 2003) demonstrates that industry growth in 1999-2002 was almost entirely determined by the higher growth of those industries oriented towards the internal market. The changes in the industrial structure have been accompanied by more rapid development of the investment sector of the economy, including machinery and the production of construction materials. Based on these facts, two additional factors have been taken into consideration as determinants of inter-regional differences in economic growth: the share of primary industries (including the fuel industry, energy, ferrous and non-ferrous metallurgy) in the regional industrial production structure and the share of machinery production in regional industry, the latter describing the dynamics of manufacturing industry.

Among the factors describing the specific features of the regional production structure, we should also evaluate the role of exports in regional development. The primary industry and exportation structure of the Russian economy has clear peculiarities in each region. The export factor plays a significant role in the development of a number of regions; moreover, the high share of export-oriented enterprises means a stable market for regional output as well as a stable income source for both enterprises and the population of the region. This factor is determined by the indicator for per capita export volume in the region[9].

The macroeconomic indicators of regional development are supposed to describe the differences in final and investment demand in the region. We were unable to obtain statistical data to evaluate the volume of final demand of households in the region. The volume of final demand can be indirectly evaluated on the basis of such indicators as the income of the population, consumption, and the volume of retail trade turnover. All of these indicators are deficient and are also closely related, so statistical criteria were used to choose one of them. Investment demand was evaluated by the indicator for the share of investment in GRP. The unemployment factor was also included as a macroeconomic indicator of regional development, although the appropriateness of such an approach is debatable. The unemployment level is generally used as one of the overall indicators of economic policy carried out in the region. We considered unemployment as an additional economic growth factor, since it implies additional labour force available in the region, which can be used without significant additional costs.

The choice of indicators of regional dynamics describing the effectiveness of economic reforms and the economic policy carried out by local and federal authorities was more complicated, due to conceptual problems on one hand, and to a lack of statistical data on the other.

The share of government expenses in GRP is generally used as an indicator of the degree of state regulation of the regional economy. This indicator is similar to the indicator of the "size of the state" used in measuring the national economy (Illarionov, Pivovarova, 2002); however, the amount of regional budget spending within a region is not directly connected to the amount of taxes collected in that region. The level of budget spending is generally higher in the "weaker" regions. Moreover, the high share of regional budget spending usually relates to the level of social costs, which does not provide for higher regional economic growth rates. Regional dynamics are directly affected by the volume of investment covered by the regional or federal budget, since both types of investment are aimed at supporting regional economic growth. The share of investment from the budget in total regional investment ranges from 0.4% to 99.6% (Republic of Ingushetia, 1999). The regional allocation of investment from the federal budget demonstrates the priorities in the economic policy of the federal government. The share of investment covered by the regional budget is determined by the economic policy of the regional authorities, which itself depends significantly on the investment capacity of the regional budget.

The success of economic reforms in the regions is often measured by the indicators of the level of development of small enterprises within the region. We have used the share of employment by small enterprises in the total volume of employment in the region as an indicator of the overall success of economic reforms. The effectiveness of market reforms can also be measured by the increase in the effectiveness of production in the region. One available statistical indicator, which describes the effectiveness of the regional economy, is the indicator inversely related to the share of loss-making enterprises in the total number of enterprises[10].

The data set was formed for the period 1999-2001 and included 237 observations for 79 administrative regions of the Russian Federation and for 21 variables. A detailed description of the data set is provided in Table A.2 in the annex.

5. Evaluation results

The following model was used to evaluate the impact of the described factors on regional economic growth:

$$Y_{rt} = a_0 + \sum_{n=0,\cdots,N} a_{nrt} X_{nrt} + c_{rt} Z_{rt} + \varepsilon_{rt}$$

where: r is the region; t = the year; n = the number of the explanatory variable; Y_{rt} = the overall result (the deviation of the regional growth rate from the average Russian rate); X_{nrt} = the explanatory variables; Z_{rt} = the indicator of specific features of the region (dummy variables); and ε_{rt} = residual factor.

The data set $\{Y_{rt}, X_{nrt}\}$ is panel data, which allows the evaluation of the impact of time and spatial changes in the explanatory variables on the overall result. Use of the first differences in the growth rates is anticipated to take into consideration the national component in economic growth. The variables of the unidentified region-specific features have been determined in the estimate based on the location of the administrative region of the Russian Federation in a given federal district, therefore such variables describe the specific features of the federal districts, particularly those that are persistent within the district.

The choice of the final regression model was made on the basis of a substantial analysis of the factors included in the model and the statistical parameters of the estimate. The Breusch and Pagan Lagrangian multiplier test for random effects has demonstrated that the fixed regional characteristics in the panel are insignificant, therefore OLS[11] may be used for estimating the regression. The results of the estimate of the regression equation for annual GRP growth rates are given in Table 6.

Table 6 Parameters of the regression equation for the annual GRP growth rates for the period 1999 -2001

	Coef.	Std. Err	t	P>[t]
Recession in industrial production (1998 to 1990)	-0.096	0.041	-2.329	0.021
Per capita GRP in 1990	-0.029	0.017	-1.679	0.095
Transportation factor	-0.108	0.044	-2.439	0.015
Share of industry in GRP	-0.134	0.054	-2.475	0.014
Share of primary sectors in industrial production	0.089	0.028	3.115	0.002
Share of machine building in industrial production	0.114	0.043	2.657	0.008
Per capita exports	-0.006	0.007	-0.885	0.377
Share of investment in fixed capital in GRP	0.072	0.010	7.158	0.000
Per capita money income of population	0.027	0.016	1.668	0.097
Share of fixed capital investment from federal budgetary funds in total investments	-0.148	0.036	-4.130	0.000
Share of fixed capital investment from regional and municipal budgetary funds in total investments	0.093	0.057	1.635	0.103
Share of employed in small enterprises	-0.242	0.121	-2.005	0.046
Dummy Central federal district	0.040	0.013	3.208	0.002
Dummy North-Western federal district	0.043	0.015	2.968	0.003
Dummy Southern federal district	0.042	0.015	2.765	0.006
Const	0.009	0.030	0.313	0.754
R-squared = 0.440 Adj R-squared = 0.402				

The factors used in the above model explain approximately one-half of all the deviations in regional growth rates from the average Russian rate (the coefficient of correlation is 44%). If a confidentiality level of 95% is used, all groups of factors appear to be statistically significant: the factors describing the initial conditions, the features of the regional economic structure, the factors describing the economic policy and the investment resources.

Among the factors describing the initial conditions for growth and the objective differences between the regions the rate of recession of industrial production and transportation factors are statistically significant. The first one (the rate of recession of industrial production) describes the basis for economic growth and is included in the regression equation with a negative multiplier, which is reasonable: the lower is the initial basis for economic growth, the higher is further economic growth. Indeed, the highest economic growth rates were demonstrated by the regions with the most severe recession, while the economic growth rates in the regions with high economic potential were generally close to the average Russian rate. The significance of the negative impact of the transportation factor for the growth rate is also clear. The initial conditions in the pre-reform period (the volume of GRP per capita for 1990, which was a significant indicator for the evaluation of the transformational recession) appear not to be statistically significant and therefore are not included in the above regression equation. Thus, the evaluation of the regression equation demonstrates that the impact of the economic situation in the regions before the reforms is not as significant as the impact of the conditions, that appeared over the course of the economic reforms (regressor of recession in industrial production).

The features of the regional economic structure are described by the following statistically significant factors: the share of industry in GRP, the share of machine building and the share of primary industries in industrial production. The share of industry in GRP is included in the regression equation with a negative multiplier, which means that higher growth rates are achieved by regions with a lower share of industry in the regional economic structure. This can also be explained by the positive impact of the share of services in the regional production structure on regional economic growth rates, which implies a lower share of industry (the positive impact of the share of services in the regional production structure has also been identified in studies of the trans formational recession).

The shares of primary industry and machine building in the regional industrial structure have a positive impact on economic growth rates and are included in the equation with positive multipliers; however, the elasticity of the share of machine building is slightly higher. As mentioned above, most of the research papers note machine building as one of the determinants of high economic growth rates during 1999-2001. However, the estimate does not allow the sectoral structure as a dominant factor in economic growth to be determined, even though the regions with a higher share of machine building in regional industry demonstrate higher economic growth rates than in regions with a lower share of machine building. This assertion is also true for regions with a higher share of primary industry (including the fuel industry, energy, ferrous and non-ferrous metallurgy). The export factor is statistically insignificant in the regression equation.

The factors relating to investment appear to be statistically significant in the regression equation. The importance of investment for economic growth is also confirmed, therefore the assertion that economic growth was a pure recovery and achieved only on the basis of the available resources is incorrect.

The sources of investment are also important. The share of investment covered by the federal budget is statistically significant, but it has a negative impact on the GRP growth rate. This can be explained by the fact that investment support from the federal budget was generally granted to underdeveloped regions with low growth rates. Investment covered by the regional and municipal budgets is statistically insignificant given the 95% confidentiality level. However, unlike investment covered by the federal budget, this factor has a positive effect on economic growth, i.e. the higher the share of investment covered by the regional and municipal budgets, the higher is regional economic growth. This can also be explained, since only the strongest regions with considerable budget resources can afford significant investment programs from local budgets.

The regressor of per capita money income of population, describing inter-regional differences in the demand of households, is statistically insignificant.

Of the factors describing economic policy and institutional change in the regions, only the share of employment by small enterprises is statistically significant. It has a negative impact on GRP growth rate, which is reasonable. Although the development of small enterprises is very important from institutional and social points of view, small enterprises usually cannot provide for high GRP growth rates, therefore their impact on the economy should be evaluated on the basis of other indicators. In our case, it is important that inter-regional differences in the level of development of small enterprises should have a significant impact on inter-regional differences in economic growth.

The regression equation includes dummy variables that have statistically significant coefficients and describe the specific features of rapid development in the western federal districts (including the Central, North-Western and the Southern federal districts), which are not explained by the factors of the model listed above. These specific features can include high population density and a higher level of economic activities in the western regions of the country, better climate, or social and political conditions in the above regions.

These common "unidentified" features of the western regions encouraged us to analyse separate regressions for the western regions[12]. The sample included the administrative regions of the Russian Federation located in the Central, the North-Western and the Southern federal districts. The statistical evaluation for the above regions appeared to be better than that for the whole country (Table 7), with the regression equation explaining approximately 52.2% of all deviations of regional economic growth rates from the average Russian growth rates.

Table 7 Parameters of the regression equation of annual GRP growth rates for the period 1999-2001 for the western regions of Russia

Factors	Coef.	Std. Err	t	P>[t]
Recession in industrial production (1998 to 1990)	-0.098	0.074	-1.329	0.187
Per capita GRP in 1990	0.018	0.039	0.465	0.643
Transportation factor	-0.706	0.062	-1.227	0.222
Share of industry in GRP	-0.224	0.099	-2.261	0.026
Share of primary sectors in industrial production	0.080	0.046	1.716	0.089
Share of machine building in industrial production	0.157	0.076	2.057	0.042
Per capital exports	0.039	0.022	1.805	0.074
Share of investment in fixed capital in GRP	0.096	0.017	5.690	0.000
Per capita money income of population	-0.043	0.029	-1.488	0.140
Share of fixed capital investment from federal budgetary funds in total investment	-0.197	0.058	-3.409	0.001
Share of fixed capital investment from regional and municipal budgetary funds in total investment	0.316	0.131	2.402	0.018
Share of employed in small enterprises	-0.539	0.193	-2.800	0.006
Const	0.045	0.059	0.771	0.443
R-squared = 0.525 Adj R-squared = 0.472				

The factor describing the initial conditions for economic growth in the regions appears to be statistically insignificant for the western regions of the country, i.e. the economic growth rates in these regions do not depend on the rate of production recession over the period of economic reforms. Inter-regional disparities in economic growth rates are determined by the specific features of the regional economic structure and the investment factor. Among the structural factors the share of industry in GRP (having a negative effect) and the share of machine building in industry (having a positive effect) have the greatest impact on the economic growth disparity. All of the factors relating to investment appear to be statistically significant, including the share of investment covered by regional and local budgets.

The regression equation for the eastern regions of the country differs significantly from the general model. The sample included administrative districts of the Russian Federation located in the Urals, and the Siberian and Far Eastern federal districts. The separate regression equation for these regions does not improve the statistical evaluation of the model, but provides for a different estimate of the influence of some factors[13]. The following factors are statistically significant in explaining the deviation of regional growth rates from the average Russian rates: the pre-reform level of development of the region (i.e. GRP for 1990), having a negative impact, and the macroeconomic factors of demand, including both consumer demand and investment demand. The factors describing the objective differences between the regions and the factors of economic policy appear to be statistically insignificant.

Economic growth in Russia in 1999-2001 was irregular and non-homogeneous. The share of regions with increasing GRP in the total GRP of Russia in 1999 was 96.5%; in 2000 this share was 98.2%, while in 2001 it was 85.2%. Accordingly, the share of regions with decreasing GRP in the total GRP of Russia in each of the years was 3.5%, 1.8% and 14.8%, respectively. Based on these differences we have tested the time effects of the discussed factors.

The factors and the conditions of economic growth are similar for the years 2000-2001, for which the model of factor evaluation is statistically significant[14]. The Breusch and Pagan Lagrangian multiplier test for random effects for the years 2000-2001 demonstrated that the fixed features of the regions do not have a significant influence on growth rates; the OLS data evaluation test is not applicable. Based on the Hausman specification test we have chosen the random effects model. The results of the evaluation of the regression equation for the years 2000-2001 are presented in Table 8.

Table 8 Parameters of the regression equation of annual GRP growth rates for the years 2000-2001

Factors	Coef.	Std. Err	t	P>[t]
Recession in industrial production (1998 to 1990)	-0.141	0.057	-2.480	0.013
Per capita GRP in 1990	-0.048	0.026	-1.831	0.067
Transportation factor	-0.150	0.062	-2.402	0.016
Share of industry in GRP	-0.099	0.074	-1.334	0.182
Share of primary sectors in industrial production	0.136	0.040	3.394	0.001
Share of machine building in industrial production	0.191	0.062	3.083	0.002
Per capita exports	-0.005	0.010	-0.506	0.613
Share of investment in fixed capital in GRP	0.085	0.014	6.124	0.000
Per capita money income of population	0.041	0.024	1.730	0.084
Share of fixed capital investment from federal budgetary funds in total investments	-0.074	0.057	-1.295	0.195
Share of fixed capital investment from regional and municipal budgetary funds in total investments	0.071	0.065	1.080	0.280
Share of employed in small enterprises	-0.209	0.171	-1.223	0.221
Dummy Central federal district	0.058	0.018	3.188	0.001
Dummy North-Western federal district	0.038	0.022	1.776	0.076
Dummy Southern federal district	0.068	0.022	3.043	0.002
Const	-0.025	0.043	-0.593	0.553
R-squared within = 0.172 Between = 0.659 Overall = 0.572				

The model for 2000-2001 contains fewer statistically significant factors that explain the deviations of the regional growth rates from the average Russian rates, compared with the general model. The narrowed set of factors explains 57% of all deviations. Statistically significant factors for 2000-2001 include the following: factors describing the starting level of development of the region (including the rate of industrial recession and the transport accessibility of the region), factors describing the production structure (the share of primary industries and the share of machine building in industrial production), the share of investment in GRP and unidentified specific features of the Central and the Southern federal districts. Given the 95% confidentiality level, the following factors relating to economic policy and institutional changes in the regions appear to be statistically insignificant: inter-regional differences in investment structure, the share of investments covered by federal and regional budgets, the level of employment by small enterprises and differences in the money income of population. Thus, inter-regional differences in economic growth rates in 2000-2001 are determined by objective differences between the regions and the production structure of each region, and are weakly dependent on the region' s economic policy.

6. Conclusion

The statistical analysis of inter-regional differences in the GRP growth rates confirmed the hypothesis that the factors of economic growth are generally the same for the national economy. Approximately one-half of all the deviations of the regional economic growth rates from the average Russian rate can be explained based on regional differences in various factors, the data for which were available to us. All of the discussed groups of factors are statistically significant in the regression equation: the factors describing the starting development level of the region, natural and geographical features of the region, production structure, economic policy factors and differences in the sufficiency of investment necessary for economic growth.

The regional growth rates depend significantly on the initial conditions existing at the time when the growth started, i.e. the results of economic development in the period 1992-1998. Although the rate of transformational recession in its turn was determined by the pre-reform development of the region (GRP per capital in 1990), inter-regional differences in growth rates in the period 1999-2001 were influenced by the rate of the production recession in 1998, rather than by the pre-reform situation. Therefore, pre-reform disparities between the regions can be considered to have been overridden, so that the current situation of each region is determined by the results of the economic reforms.

Regional economic growth rates are not explicitly dominated by sectoral structure. Higher (or lower) economic growth rates are demonstrated by both types of region: both regions in which primary industry is predominant in the industrial structure, and regions where manufacturing industry is predominant. Both a high share of primary industry and a high share of machinery building in industrial production have a positive effect on economic growth, but a more detailed analysis demonstrates that the share of machinery building in industry is only significant for western regions of the country, while in eastern regions, inter-regional disparities in economic growth are not influenced significantly by the production structure.

The export factor has only a slight effect on inter-regional differences in economic growth. Regions in which exports account for a significant share in the production structure have suffered less from the transformational recession, since the recession rate was close to the average Russian rate. However, during periods of economic growth, such regions do not demonstrate high economic growth rates, and generally correspond to the average Russian growth rate.

The estimate confirms the importance of investments for economic growth and demonstrates that economic growth is not a pure restoration. It is more likely that economic growth was a restoration during 1999, when the number and the impact of economic factors differed from those effective in 2000-2001. Economic growth over 2000-2001 fits into the pattern of macroeconomic growth to a greater extent, with investment the main factor in such growth.

The assertion of the influence of economic policy and regional economic reforms on inter-regional disparities is also confirmed by estimates. The level of development of small enterprises in the region is one of the factors of economic growth, which however has a negative effect. Small enterprises can resolve the problems of unemployment and the level of income of the population, but do not allow high GRP growth rates to be attained.

The share of investment covered from the federal budget in the total amount of regional investment has a significant impact on regional economic growth rates, but the effect is negative. The high share of federal investment does not imply high economic growth in the region, i.e. federal investment has a compensatory rather than a stimulating effect. Regional investment has the "right" influence, but is not statistically significant given the 95% confidentiality level.

Unidentified region-specific features appear to be statistically significant for the regions with the highest economic growth rates_the Central, the North-Western and the Southern federal districts (the Central and Southern federal districts only in 2000-2001). These factors can include a favourable climate and geographical conditions, the possibility of realizing an agglomeration effect and the economic activities of the regional authorities.

Notes

1 In accordance with the constitution, the Russian Federation is divided into 89 administrative regions that belong to one of seven federal districts (*federal'nye okruga*). The country is also divided into eleven economic regions (ekonomicheskie raiony) and both the economic region and federal district groupings are used for the purposes of aggregate analysis. The city of Moscow is the administrative region with the largest population, totalling 8.539 million people as of 1st January 2002, almost 480 times larger than the population in Evenk autonomous okrug, which is the smallest administrative region in terms of population size. In 2000, the value of the regional product in the administrative region with the highest economic potential, the city of Moscow, was 357 times higher than the production volume in the region with the lowest economic potential, the Republic of Tyva. There are also considerable differences in the per capita production rate, so per capita GRP in Tyumen oblast in 2000 was 20 times higher than in the Republic of Dagestan. The population in the Central federal district, which has the largest population, was 5.2 times greater than the population in the Far Eastern federal district, which had the smallest population (as of 1st January 2002). GRP in 2000 in the largest federal district, the Central federal district, was 6.5 times greater than GRP in the federal district with the lowest economic potential, the Far Eastern federal district; per capita GRP in the Urals was 3.2 times greater than in the Southern federal districts (the ones with the greatest and lowest levels, respectively) (Goskomstat, 2002).

2 Data for the Russian Federation included the sum of GRP for all administrative regions of the Federation, it is less useful than GDP for estimating economic activity relating to the national economy that is not divided up between regions.

3 The most recent official data published by Goskomstat is that for 2000, therefore we have used the evaluation of GRP in each administrative region of the Russian Federation in 2001 made by A. Granberg and Yu. Zaitseva (Granberg, Zaitseva, 2002) for 79 subjects of RF. The data for 9 autonomous districts (excluding Chukotsky Autonomous Okrug) were included in the indicators for the relevant administrative regions.

4 Available statistical information was taken into consideration in choosing the indicators.

5 Since the federal districts were established in 1999, an analysis of the regional proportions in 1990-1999 has been carried out for the economic regions of the Russian Federation. However, both groupings reflect the development shares of the largest regions of the country.

6 The trends in the production structure for the period 1999-2002 are exactly the same as those for the period 1999-2001; only the values of the indicators have changed.

7 The federal district to which the administrative region is affiliated is given in brackets. CFD - Central federal district, NWFD - North-Western federal district, PFD - Privolzhsky federal district, SFD-Southern federal district, UFD - Urals federal district, SibFD - Siberian federal district, FEFD - Far Eastern federal district.

8 The Barro specification and the Levine-Renelt specification have been tested on the basis of the data

for 79 Russian regions over the period of 1999-2001. The factors included in the model explain at most 15% of the inter-regional differences in economic growth rates, and statistically significant factors included only the variable describing the initial conditions within the region and the investment growth rate, given a 95% confidence level.
[9] The share of exports in gross regional product better describes the export orientation of the regional production structure. However, no data on the gross regional product for the given period were available to us. Moreover, we have used an expert evaluation of the value of GRP in fixed prices for 2001, therefore the indicator of the dollar value of per capita exports appears to be more reliable.
[10] Data on the profitability of industrial enterprises are available, but are incomplete and therefore do not permit the overall evaluation of profitability in regions with a high share of agriculture or transportation.
[11] Evaluations of the parameters of the regression equations were carried out with the use of the statistical analysis software STATA
[12] The regression equation was also evaluated for the four western federal districts - the Central, North-Western, Southern and Privolzhsky federal districts. The evaluation of the regression equation does not deviate significantly from the evaluation for the general regression equation, with all of the regressors maintaining the same (positive/negative) relations with the overall result. Unlike in the general model, two of the regressors appear to be statistically insignificant: the rate of the production recession in 1990-1998 and the share of primary industry in the production structure. Given a 95% confidentiality level, the share of investment from the regional budget becomes statistically significant. Details of the evaluation are given in Table A3 of the annex. R^2 is 0.462.
[13] The evaluation of the regression equation for the eastern regions is given in Table A4 of the annex.
[14] The regression equation for the year 1999 has only two statistically significant regressors: the share of investment in GRP and the share of investment covered by the federal budget. R^2 is 0.292.

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APPENDIX.

Table A-1.
Average annual growth rates of the major economic indicators in the federal districts of the Russian Federation in 1999-2002

(%)

Federal district	1999	2000	2001	2002	Average annual rate
GRP					
Russian Federation	5.6	10.7	4.9	...	7.0
Central	6.3	14.9	6.8	...	9.3
North-Western	7.5	9.9	2.7	...	6.7
Southern	8.7	11.6	7.8	...	9.4
Privolzhsky	5.2	8.4	2.8	...	5.4
Urals	2.8	10.2	5.7	...	6.2
Siberian	4.4	7.6	3.7	...	5.2
Far Eastern	6.2	3.1	0.0	...	3.1
Industrial production					
Russian Federation	11.0	12.0	5.0	3.7	6.8
Central	...	15.0	10.0	7.8	10.9
North-Western	...	23.0	3.0	16.4	13.8
Southern	...	16.0	13.0	3.2	10.6
Privolzhsky	...	11.0	5.0	2.2	6.0
Urals	...	11.0	6.0	5.4	7.4
Siberian	...	9.0	7.0	4.0	6.6
Far Eastern	...	7.0	-0.1	-0.9	1.9
Agricultural production					
Russian Federation	4.0	8.0	8.0	1.7	5.4
Central	-2.0	14.0	0.3	2.0	3.4
North-Western	10.0	4.0	3.0	0.4	4.3
Southern	8.0	10.0	15.0	7.4	10.1
Privolzhsky	8.0	2.0	10.0	-0.1	4.9
Urals	14.0	-3.0	7.0	-2.3	3.7
Siberian	2.0	12.0	8.0	-1.0	5.1
Far Eastern	-6.0	-0.1	9.0	4.0	1.6
Investment in fixed capital					
Russian Federation	5.0	17.0	9.0	...	10.2
Central	8.0	13.0	-7.0	...	4.3
North-Western	27.0	7.0	11.0	...	14.7
Southern	22.0	56.0	-5.0	...	21.8
Privolzhsky	5.0	25.0	1.0	...	09.9
Urals	15.0	53.0	14.0	...	26.1
Siberian	5.0	18.0	7.0	...	9.9
Far Eastern	44.0	-2.0	32.0	...	23.0

Investment in fixed capital					
Russian Federation	5.0	17.0	9.0	...	10.2
Central	8.0	13.0	-7.0	...	4.3
North-Western	27.0	7.0	11.0	...	14.7
Southern	22.0	56.0	-5.0	...	21.8
Privolzhsky	5.0	25.0	1.0	...	09.9
Urals	15.0	53.0	14.0	...	26.1
Siberian	5.0	18.0	7.0	...	9.9
Far Eastern	44.0	-2.0	32.0	...	23.0
Retail trade turnover					
Russian Federation	-6.5	8.7	10.7	9.1	5.3
Central	-14.9	5.7	7.2	5.1	0.3
North-Western	-10.3	8.7	11.5	8.5	4.2
Southern	-6.4	13.4	10.3	12.9	7.2
Privolzhsky	-12.2	2.9	9.3	9.4	1.9
Urals	-14.3	10.4	13.7	15.1	5.5
Siberian	-11.5	10.0	11.7	12.9	5.3
Far Eastern	-8.2	2.7	11.1	13.4	4.4
Real disposable money income of population					
Russian Federation	...	...	10.0	7.2	8.6
Central	...	...	9.0	8.1	8.5
North-Western	...	...	10.0	6.9	8.4
Southern	...	...	10.0	12.9	11.4
Privolzhsky	...	...	10.0	12.1	11.0
Urals	...	...	12.0	11.5	11.7
Siberian	...	...	9.0	15.0	12.0
Far Eastern	...	...	9.0	13.5	11.2

Source: Compiled on the basis of: Goskomstat RF, 2001; Goskomstat RF, 2002; Goskomstat RF, 2003; Granberg, Zaitseva, 2002)

Table A-2.
Parameter estimates for the regression of the GRP growth rate from various factors (t-statistics shown in brackets)

	Independent variables	a	B	R^2	Mean
Factors describing the starting level of development and objective differences between regions					
1	Recession in industry (index of industrial production in 1998 to 1990)	0.028 (1.870)	-0.064 (-1.861)	0.010	0.416
2	Per capita GRP in 1998 at 1990 prices	0.018 (1.937)	-0.019 (-2.070)	0.018	0.862
3	Per capita GRP in 1990	0.039 (3.427)	-0.038 (3.427)	0.049	0.981
4	Transportation factor (density of transportation roots in region)	-0.007 (-0.814)	0.045 (1.258)	0.007	0.183
5	Integrated indicator of objective differences between regions	0.018 (2.286)	-0.011 (-2.625)	0.029	1.423
Factors describing specific features of the regional production structure					
6	Share of primary sectors in industry	-0.001 (-0.188)	0.011 (0.571)	0.001	0.264
7	Share of machine building sector in industry	0.007 (0.901)	-0.030 (-0.877)	0.003	0.186
8	Share of industrial production in GRP	0.047 (3.630)	-0.138 (-3.765)	0.057	0.330
9	Share of agricultural production in GRP	0.001 (0.117)	0.004 (0.064)	0.000	0.122
10	Per capita exports	0.000 (0.069)	0.002 (0.353)	0.000	0.653
Macroeconomic factors					
11	Share of fixed capital investment in GRP	-0.080 (-7.982)	0.083 (8.984)	0.256	0.983
12	Foreign investment per capita	-0.000 (-0.036)	0.003 (1.036)	0.005	0.700
13	Per capita money income of population	0.008 (0.837)	-0.008 (-0.776)	0.003	0.820
14	Per capita money expenditure of population	0.005 (0.572)	-0.042 (-0.642)	0.001	0.745
15	Retail trade turnover	0.003 (0.322)	-0.001 (-0.159)	0.001	0.743
16	Unemployment level	-0.023 (-1.931)	0.195 (2.268)	0.021	0.125
Economic policy and institutions					
17	Share of budgetary expenditure in GRP	0.021 (1.742)	-0.099 (-1.756)	0.013	0.196
18	Share of fixed capital investment from federal budgetary funds in total investment	0.012 (1.830)	-0.082 (-2.300)	0.022	0.129
19	Share of fixed capital investment from regional and municipal budgetary funds in total investment	0.000 (0.045)	0.015 (0.247)	0.000	0.088
20	Share of employed in small enterprises	0.010 (0.917)	-0.104 (-0.858)	0.003	0.081
21	Share of lossmaking enterprises	0.040 (1.711)	-0.088 (-1.678)	0.012	0.433

Table A-3.
Parameters of the regression equation of annual GRP growth rates for the period 1999-2001 for the Central, North-Western, Southern, and Privolzhsky federal districts

Factors	Coef.	Std. Err	t	P>[t]
Recession in industrial production (1998 to 1990)	-0.132	0.054	-2.450	0.015
Per capita GRP in 1990	-0.019	0.034	0.566	0.572
Transportation factor	-0.051	0.053	-0.972	0.333
Share of industry in GRP	-0.282	0.079	-3.572	0.000
Share of primary sectors in industrial production	0.087	0.039	2.234	0.010
Share of machine building in industrial production	0.069	0.050	1.369	0.173
Per capita exports	0.034	0.019	1.742	0.084
Share of fixed capital investment in GRP	0.082	0.015	5.581	0.000
Per capita money income of population	-0.025	0.026	-0.948	0.345
Share of fixed capital investment from federal budgetary funds in total investment	-0.188	0.051	-3.723	0.000
Share of fixed capital investment from regional and municipal budgetary funds in total investment	0.048	0.092	0.527	0.599
Share of employed in small enterprises	-0.412	0.166	-2.484	0.014
Const	0.089	0.050	1.784	0.077
R-squared = 0.463 Adj R-squared = 0.420				

Table A-4
Parameters of the regression equation of the annual GRP growth rates for the years 1999-2001 for eastern regions of Russia (Urals, Siberian, Far Eastern federal districts)

Factors	Coef.	Std. Err	t	P>[t]
Recession of industrial production (1998 to 1990)	-0.054	0.060	-0.898	0.373
Per capita GRP in 1990	-0.131	0.033	-3.963	0.000
Transportation factor	0.062	0.146	0.425	0.673
Share of industry in GRP	-0.035	0.081	-0.425	0.672
Share of primary sectors in industrial production	0.003	0.042	-0.076	0.940
Share of machine building in industrial production	-0.014	0.076	-0.178	0.859
Per capita exports	-0.012	0.006	-1.949	0.056
Share of fixed capital investment in GRP	0.056	0.015	3.715	0.000
Per capita money income of population	0.027	0.016	1.668	0.097
Share of fixed capital investment from federal budgetary funds in total investment	-0.048	0.055	-0.863	0.391
Share of fixed capital investment from regional and municipal budgetary funds in total investment	-0.003	0.062	-0.053	0.958
Share of employed in small enterprises	-0.037	0.207	-0.179	0.859
Const	0.001	0.048	0.036	0.971
R-squared = 0.442 Adj R-squared = 0.334				

Financial Reforms and Deposit Behavior in Bangladesh, India and Pakistan: A Vector Auto-Regression Analysis

MD. Akhtar Uzzaman* & Yoshiro Higano**

Abstract

The paper employs both the co-integration and vector auto-regression (VAR) techniques to identify the variables that are believed to influence variation in different types of deposit growth behavior in Bangladesh, India and Pakistan. The results of our co-integration support the hypothesis that various deposits are positively related to economic growth and also have long-run equilibrium relations with other variables, such as deposit interest rates, inflation expectation, bank branch growth and growth of bank credit. It is also observed in the FEVs (from VAR estimates) that the growth of real GDP and interest rates are the two most important determinants, jointly accounting for 50.0% to 60.0% of the variance of various types of deposit growth in Bangladesh and aggregate deposit growth in India and Pakistan. Households' expectations of inflation, the growth of bank branches and the growth of bank credit also appeared to reflect reasonably strong influences (each of them is accounting for 10.0% to 20.0% on average) on the variance of various types of deposit growth in Bangladesh as well as in the variance of aggregate deposit growth in India and Pakistan. So, given the findings present empirical study, it seems important to take these determinants into account in forecasting the future value of various types of deposit growth in order to ensure more effective monetary policy in these countries with regard to deposit and investment growth. The results are also instructive for Northeast Asian countries with similar experiences of financial reform.

KEYWORDS: *Deposit mobilization, Bank credit, Co-integration, Forecast error variance (FEV), Vector auto-regression (VAR)*

1. Introduction

The mobilization of deposits is one of the most important sources of funding in the financial market. In fact, deposit collection is the primary source of funding in the banking sector and as such it provides a major part of the supply of credit in the economy. Deposit collection is essential because it ensures an adequate supply of credit to satisfy the credit demands of the productive sectors of the economy. Large fluctuations in trends in deposit growth have serious implications for a number of macroeconomic variables including such important macroeconomic and monetary variables as the growth of investment and bank credit, and economic growth in general. Furthermore, when deposit mobilization is poor and insufficient to satisfy credit demand, banks have to rely heavily on borrowing from the central bank, which has a substantial impact on overall price levels in the economy. Therefore, a study of broad trends in the growth of bank deposits that identifies its important determinants is crucial both for commercial banks as well as for the central bank. Moreover, identifying the real determinants of deposit behavior of the economic agents is

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central to the analysis of financial sector fund management and credit growth. It has equally important implications for controlling the money supply in order to ensure price stability and hence, for adopting an appropriate monetary policy.

From the liability side, deposits constitute the lion's share of the money supply and therefore it is essential that the central bank of the country is familiar with the processes and determinants of deposits because it has to design monetary policy and control the money supply in line with the economy's demand for money, which has a significant impact on interest rates and price levels. Hence, the purpose of the present paper is to identify the long-run as well as short-run determinants of deposit growth in the context of three neighboring South Asian countries: Bangladesh, India and Pakistan.

The remainder of the paper will be divided into five sections. In Section I we outline some important features of growth trends among different types of deposit in Bangladesh and broad features of aggregate deposit trends in the economies of India and Pakistan. Section II discusses the basic features of financial sector reforms and their potential impact on deposit growth trends in Bangladesh, India and Pakistan. In Section III we analyze the important determinants of different types of deposit from a theoretical viewpoint in order to construct an empirical VAR model. In Section IV we describe the database and empirical methodology, and subsequently analyze the results of an econometric estimate of the co-integration function and the VAR model. Finally, in Section V we provide a brief summary of our study in the form of a conclusion and an outline of some policy implications consistent with our empirical results.

2. Current Deposit Trends: The Experiences of Bangladesh, India and Pakistan

There has been an increase in the growth rate of aggregate deposits in the banking system of Bangladesh, ranging from an average growth rate of 20.0% during the pre-reform period (1973-1982) to 22.0% in the period of intensive reforms (1983-1992) and an average growth rate of 14.0% in the post-reform period (1993-2002) (Table A). This kind of experience of a significantly positive average growth rate for total deposits is encouraging for the economy, especially over a relatively long period of time. The most notable feature of this high deposit growth is that the lion's share of the growth was accounted for by time deposits rather than by demand deposits.

Time deposits have recorded an average growth rate ranging from 27.0% in the pre-reform period (1973-82) to 23.0% in the period of intensive reforms (1983-92) and to 15.0% in the post-reform period (1993-2002). Consistent with trends in time deposits, the fixed deposit (3 months + 6 months + saving deposits) has also recorded a much higher growth rate (almost the same growth level as time deposits) compared with current deposits. Secondly, a higher, continuously rising growth trend is particularly discernible with regard to time deposits as well as with regard to trends in fixed deposits. The share accounted for by time deposits (or fixed deposits) in total deposits has been gradually rising from 57% (65% for fixed deposits) in the pre-reform period to 75.0% (80% for fixed deposits) in the period of intensive reforms and to 83.0% (85% for fixed deposits) in the post-reform period.

Thirdly, the share of urban deposits in total deposits is also spectacular, constituting almost 85% on average (ranging from 92% in 1973 to 77% in 2002) of total deposits. It is notable that the share of urban deposits has registered a decline, albeit a slow one, which means that banking services have spread into rural areas. Later in our empirical analysis we will see that the growth of bank branches is a more important determinant of rural deposits than of urban deposits. Fourthly, the common characteristic of demand deposit (or current deposit) growth is that there are short-run seasonal fluctuations affecting long-run trends due to seasonality in business activities, such as the window dressing effect.

In fact, the third quarter of the calendar year (July-September) is the first quarter of the fiscal year, when business activities do not normally get momentum and demand deposits decline. However, in the fourth quarter of the calendar year (October-December) the collection of demand deposits normally gets momentum due to significant swings in economic activities. Moreover, in the fourth quarter, business activities in the financial sector follow a peak high trend. In addition, financial institutions treat the fourth quarter as their last or closing quarter, so they try to attain the maximum rate of demand deposit growth, even if it means taking credit from the central bank in order to ensure a healthy balance sheet. This common, seasonal phenomenon is known as window dressing and is the reason why demand deposits (or current deposits) always register very high positive growth in the fourth quarter.

For the same reason as in the third quarter of the calendar year, the growth of demand deposits in the first quarter of the calendar year normally registers a negative growth rate, as business activities in the financial sector are more-or-less dormant. Accordingly, negative growth in demand deposits or current deposits in the first quarter of the banking sector calendar year (Jan-Mar) is fairly common trend.

In the Indian case, deposit growth also rose at a higher rate during 1970s (an average of more than 21%) and rose at an average of 18% during the 1980s; in the last decade the growth has been a little lower, with aggregate deposits registering an average growth rate of about 17% per annum over the period, a figure that is substantial for such a large, growing economy. The Indian economy also experiences seasonal fluctuations of deposit growth attributable to the same reason as business fluctuations in Bangladesh.

In the case of Pakistan the growth rate of aggregate deposit is different from Bangladesh and India in the sense that it has recorded a very high rate of deposit growth, reaching more than 23% on average during the latter half of the 1970s and an average of 16% during the 1980s but deposit growth has slowed down in the last decade. The growth rate of deposits in Pakistan during the 1990s was much lower than in the past, with the country recording an average deposit growth rate of only 13%.

3. Financial Reforms and their Potential Impact on Deposit Behavior

During the last two decades (1980s and 1990s), the financial sector in Bangladesh has undergone deep and radical changes with the aim of realizing modernization in the banking services and achieving greater financial deepening in the monetary sector through major financial liberalization measures and the implementation of various reform policies since the mid-1980s. In fact, Bangladesh's most intensive period of financial sector reform programs was in 1983-1992. Many important liberalization policies have already been implemented in the financial sector, such as the liberalization of deposit and lending interest rates, more flexible and transparent rules for opening new banks in the private sector and the removal of government restrictions and controls over exchange rates and capital flows.

As a result of all these steps, firstly, during the period 1982-2002, more than 40 new banks and non-bank financial institutions were set up and began operating in the private sector. Secondly, as part of the privatization process, two public banks were denationalized in 1983/84 and the government decided to sell 49% of the shares of 3 (out of 4) other nationalized banks. Thirdly, in addition to a number of gradual upward adjustments of the nominal interest rate on deposits and loans, the central bank (Bangladesh Bank) instituted a new interest rate policy in January 1990. Under this new policy, the Bangladesh Bank defines floor and ceiling rates on deposits and loans. The commercial banks are then free to establish the exact interest rates on deposits and loans within a 1% range of the upper and lower bands. The Bangladesh Bank adjusts the floor and ceiling rates on deposits and lending rates every six months according to market conditions and the requirements of sound monetary policy. In 1994, while retaining control of the floor rate, Bangladesh Bank abolished the ceiling rates on all types of deposit in order to allow the market economy greater freedom in determining interest rates. Accordingly, since the mid-1990s, market forces have had a greater impact both on deposits and lending interest rates in the financial sector of the Bangladesh economy. Similar efforts have also been made by the central banks of both India (Reserve Bank of India) and Pakistan during the same period.

Fourthly, efforts have been made to create greater competitiveness and a sound financial sector through more effective central bank supervision, transparent regulatory laws and control and strict compliance with statutory reserve requirements by commercial banks, as well as the elimination of barriers to entry into the banking industry, along with higher capital requirements. Fifthly, most of the commercial banks have made progress in computerizing their banking services, thereby improving the service quality of such banking activities as credit disbursements and deposit collections. Finally, the establishment of many new generation private banks (both local, foreign and joint venture) created a more competitive environment, with different types of financial instruments and derivatives being introduced and the potential for a higher rate of deposit collection being enhanced.

India's experience of financial liberalization is more or less similar but the pace, time period and pattern is slightly different. In India, financial reforms and trade reforms were initiated in the early eighties but the pace of implementation is much slower than in Bangladesh. Of course, the interest rate in India is relatively flexible and determined by the market, and therefore might be more effective in influencing deposit behavior.

Pakistan also initiated financial reforms and trade reforms in the early eighties, but their experience of implementation has been the same as that of Bangladesh.

Although many measures to reform the financial and trade sector have been implemented quickly, the interest rate has became more flexible and more market-determined than that of Bangladesh and may exert a substantial influence on deposit behavior.

All the measures aimed at liberalizing the financial sectors in these three countries have significant implications for the behavior of deposit growth in the economy of Bangladesh, India and Pakistan because, with the removal of all direct controls over monetary variables, interest rates are now more freely determined by market forces and hence have begun to play a greater role in transmitting the effects of monetary policy to the real sector of the economy. Accordingly, financial liberalization measures may cause greater interest rate sensitivity in deposit behavior in those countries. In the empirical section we will evaluate this phenomenon.

4. The Interpretation of Deposit Behavior in Economic Theory

Deposits are generated by household, business and public sector savings and these savings are primarily dependent on the level of income of each category of economic agent as mentioned in the foregoing theoretical discussion. Savings are generated when these economic agents have income greater than expenditure; when this surplus is transferred into different accounts through banks and other financial institutions then it is called a deposit and hence the primary determinant of deposits is essentially national or individual income. When we make a deposit into a bank account we expect some return as compensation for losing the opportunity to earn more money from that surplus and also as compensation for losing the purchasing power of the amount deposited due to inflation. Accordingly, two other important determinants are the rate of interest and expectation of inflation. Other factors that influence deposits will be discussed below.

4.1 GDP as a Determinant of Deposits

Theoretically, the biggest potential determinant or source of deposits is GDP. With an increase in individual income or growth in per capita GDP, people would have a greater surplus to save and deposit in the bank, while conversely, with a deceleration in economic growth, people would have less capacity to save and the growth in deposits would decline. Thus, bank deposits are positively related to GDP growth. In the context of a growing economy like Bangladesh, apart from increasing the transaction demand for money, an increase in national income would also increase the savings of the community. Since part of the savings would be in the form of time and savings deposits, the aggregate deposits of the banking system would be positively related to income.

4.2 Advances as a Determinant of Deposits

It should be noted that the slow growth of bank credit can, in general, cause lower growth in deposits. In fact, the slow rate of economic growth indicates that economic activities have slowed down and there is less demand for bank credit in the financial market. Bank credit is defined as commercial bills, loans and advances plus investment. As the demand for goods and services is directly influenced by the increase in national income, the higher the income the higher the demand for bank advances. As output increases, the banking system increases its loans and advances, which can only be made if deposits in the banking system increase. Therefore, it is evident that advances themselves create deposits. When the banking system increases its advances, the cheques drawn are paid to various parties who in turn deposit these in their respective bank accounts. Consequently, deposits in the banking system as a whole would increase.

Leakage from advances would occur in the form of cheques drawn and paid in cash. With such leakages in the form of cash withdrawals, the relationship between advances and new deposits reflects the basic habits and propensities of people. In fact, these reflect a kind of cash balance which the public wishes to maintain with itself in relation to bank deposits. In a poor economy, currency held by the public constitutes a large part of the total money supply and consequently makes up a large proportion of total deposits. Accordingly, there would be a sizeable leakage from new advances in the form of cash and re-deposits in relation to new advances would be smaller. This in turn would hamper the banking system' s capacity to advance more to various sectors, since these advances must respect cash and liquidity ratios, which would undoubtedly suffer downward pressure in such circumstances.

Furthermore, it should be noted that not all increases in bank deposits arise from increases in advances. If structural changes in banking habits and other institutional improvements took place in a society, deposits would increase independently of an increase in advances. However, times when such structural changes of habit are taking place are generally also times when the banking system is playing a dynamic and expansionist role in terms of increasing lending. It follows that if advances are to rise continuously in order to meet the requirements of increased investment and output, it would be necessary for the banking system to keep on mobilizing a large and growing proportion of advances in the shape of deposits. It would also help to influence deposits if the public' s habits regarding the conventional ratio of currency holdings to bank deposits continued to move in the direction of using less currency and more bank deposits. Deposits would also be impacted if changes in institutional practices increasingly caused the public and institutions to turn to the banking system.

4.3 Inflation as a Determinant of Deposits

With an inflationary situation, apart from a decline in the transaction demand for money, savings will also respond positively. These savings will lead to aggregate deposits. The logic is simple: when the rate of inflation increases, there will be higher individual, corporate or enterprise profits and, if rich people constitute the majority of savings account holders (mainly in the form of time deposits), then higher inflation will increase deposits. Again, the opposite effect (a negative impact) will be generated for relatively less well-to-do people because a major portion of their income goes on consumption and whenever there is an upward movement in price levels, these people will be forced to withdraw their savings or abandon their new saving decisions to cover their enhanced daily expenditure arising from the higher price level. In the context of Bangladesh, banking statistics shows that more than

70% of the total number of accounts are in the category of savings accounts. This implies that most middle and lower middle class people have savings accounts, accounting for more than 30% of total deposits in the economy. Therefore, the rate of inflation could have a negative effect on deposit growth.

4.4 Interest Rates as a Determinant of Deposits

By keeping their money in a bank, people lose the potential gain in alternative use as reflected by opportunity cost, so banks compensate them by paying interest on their deposits. This implies that an increase in the interest rate on deposits ought to increase the demand for deposits and thus, the higher the interest rate offered by the banks, the more people will be motivated to make deposits.

Against this argument, it is said that in many empirical studies of the Bangladesh economy, researchers found that a large number of directly related monetary variables, such as deposits, credit and investment, have no elastic relationship to the rate of interest, but this may not always be true (the case of low interest rate sensitivity) - particularly in the long run - due to several reasons, of which the effects of financial liberalization reforms are the most important factor.

In fact, one of the main objectives of reforms is to make the interest rate more freely determined or in other words, to be more determined by the market, which in turn enhances interest rate sensitivity for many macroeconomic variables, including deposit growth. In our empirical analysis (section IV) we will test this hypothesis.

4.5 Growth of Bank Branches as a Determinant of Deposits

Several alternatives can be considered to be a proxy for financial development; one of these is the growth of financial institutions, i.e. an increase in the number of bank branches. In fact, one of the indicators of the spread of banking services is growth in the number of bank branches. Accordingly, it is generally expected that the higher the number of bank branches, the higher will be the volume of bank deposits.

Three main factors - time, security of the journey and cost of transportation - usually encourage people to deposit more in the bank if banking services are available near their residence or workplace. This is more so in an underdeveloped country like Bangladesh, where banking services are not yet widespread. Many empirical studies have also demonstrated a positive relationship between the number of bank branches and the size of bank deposits. Although the number of bank branches may be positively related to bank deposits in some developing countries, the number of bank branches may not always be a good proxy for financial development and one of our primary aims in this study is to verify this issue empirically.

Banks contribute to economic development by acting as an intermediary for the provision of funds from surplus-spending households units to deficit-spending business sectors. The intermediary approach treats banks as collectors of funds which are then used for loans and to create other assets. Accordingly, it is expected that bank output will increase in terms of different deposits as the banking industry develops.

5. Database, Empirical Methodology and Results of Estimates

5.1 Database

The database used in our econometric estimates was partly taken from the International Financial Statistics (IFS) of International Monetary Fund (IMF), and partly from Bangladesh Bank Economic Trends (monthly) and the Bangladesh Bank Quarterly Bulletin for the period 1973I to 2002V. In the cases of India and Pakistan, all data are yearly and taken from IFS.

The nominal narrow money supply, M1, consists of currency outside the banks and demand deposits at banks. The nominal broad money supply, M2, consists of M1 plus the sum of quasi money that consists of time deposits, savings deposits and foreign currency deposits held by all depositors excepting government deposits.

Demand deposits, DD, includes all short-term deposits, such as all checkable and current account deposits, travelers checks, IOUs and savings deposits of less than 3 months term etc. (see lines 24 and 25, IMF International Financial Statistics), whereas current deposits consists solely of money deposited in a current account that may be withdrawn at call or demand (see the Bangladesh Bank Quarterly Bulletin). Time deposits, TD, comprises all long term deposits, such as fixed deposits and saving deposits for terms of 3 months or longer (see IFS line 25) whereas fixed deposits consists solely of money deposited in a fixed account for terms of 3 months or longer (see the Bangladesh Bank Quarterly Bulletin). Urban deposits comprises all types of deposit, such as DD and TD that are collected from financial institutions in urban areas, with rural deposits consisting of all deposits from financial institutions in rural areas.

We preferred to use quarterly data for Bangladesh, thereby actually improving the power of the test statistic by increasing the number of observations to 120. In the case of Bangladesh, one of the limitations of using quarterly data sets is that there is no quarterly data for GDP. However, data on agricultural production is available on a quarterly basis and therefore, to overcome this problem, we have used our own method to estimate quarterly GDP data[1]. Real GDP is in 1995 constant prices for all three countries.

The weighted average deposit interest rate and the 1995 consumer price index (CPI) are used for Bangladesh, while for India and Pakistan a simple average deposit interest rate is used due to the limitations of available data.

5.2 Empirical Methodology and Analysis of the Results of Econometric Estimates

In identifying potential determinants or explanatory variables of deposits, we initially made an attempt separately to estimate the factors affecting different types of deposit, such as total deposits, time deposits, demand deposits, current deposits, fixed deposits, rural deposits and urban deposits, because there is always a possibility of substitution between one type of deposit and another. Having established the vector of variables of interest in our deposit behavior models, we moved on to econometric estimates. The empirical analysis pursued involves a number of steps.

Firstly, unit root tests are conducted to determine whether the variables included in the empirical analysis are stationary and also the order of integration of each series. Secondly, the co-integration relationship between different types of deposit and the variables specified in models (see section-III) were tested. We obtained seven co-integrating relationships using seven alternative definitions of deposit functions which show correct signs for independent variables. Finally we estimated the forecast error variance following variance decomposition of the variables in interest using the Vector Auto Regressive (VAR) Model, which we will discuss subsequently in this section.

5.2.1 Stationarity Properties of Time Series Data

To develop a meaningful understanding of the relationship between two or more economic variables using regression techniques, we need to ensure that the time series (TS) demonstrates some stationarity properties. In other words, any regression results with non-stationary TS demonstrate spurious relationships between variables and therefore give rise to misleading implications regarding the relationship. For example, shocks to the stationary TS are necessarily temporary; over time, the effects of the shocks dissipate and the series will revert to its long-run equilibrium value while shocks to the non-stationary TS make it explosive.

Non-stationarity in TS generally arises from the presence of trends in the data which are stochastic in nature (random walk process) and it confirms that the data have a unit root process. Therefore, the variables in the economic model must be tested in order to checking its stationarity properties and the order of long-run integration prior to estimating a statistical relationship between economic variables.

The stationarity tests in the TS of all the variables in question are performed by applying the popular Augmented Dickey-Fuller (ADF) test[2]. Additionally, the Phillips-Perron test is also carried out in order to compare the results, but these are only mentioned in cases where there are significant differences between the two test statistics, ADF and PP.

5.2.2 Results of the Unit Root Test

The results of the ADF unit root test that was applied in cases both with and without time trend specifications are presented separately in Table 1. The results of the estimates show that the null hypothesis, H_0, (with unit roots) cannot be rejected for most of the variables in question for Bangladesh, that is, the log of total deposits ($Ltdeposit_t$), urban deposits ($Lurdeposit_t$), rural deposits ($Lrrdeposit_t$), time deposits ($Ltmdeposit_t$), demand deposits ($Lddeposit_t$), fixed deposits ($Lfxdeposit_t$), current deposits ($Lcrdeposit_t$), total bank credit ($Ltadvance_t$), rural bank credit ($Lrradvance_t$), urban bank credit ($Luradvance_t$) and the log of the total number of bank branches ($Lbbranch_t$), the expected rate of inflation (Δp_{t-1}), the deposit interest rate ($DEPOINT_t$) and the fixed deposit interest rate ($FIXEDINT_t$) are all non-stationary in level form in cases both with and without time trend.

For the variable y_t (in level form) we found that it is non-stationary in the no time trend fit but stationary in the fit with time trend; however, when we considered the PP statistic, it could not reject the null of the unit root in the fit with time trend where the PP statistic value is shown in parentheses.

The three other variables for Bangladesh: $Ltadvance_t$, $Lfxdeposit_t$, and $Lrradvance_t$, are seen to be stationary in level form for the cases of no time trend but for the first two variables the null of the unit root is rejected at a very low level of significance (at only the 10% level) and for the variables $Lrradvance_t$ the null is rejected at the 1% level. When we considered the PP statistic for all three variables, it could not reject the null of unit root in the fit with the "no time trend" where the PP statistic values are shown in parentheses. For two other variables; $Lbbranch_t$ and $Ltmdeposit_t$ we observed a situation in which these variables were shown to be non-stationary not only in level form (in no time trend fit) but also in the first difference form; however, when applying the PP test all were shown to be stationary in the first difference form (see figures in parentheses). Accordingly, after observing the difference in the unit root test results for ADF and PP statistics for the foregoing five variables, these variables were also included in the co-integration analysis.

The estimated results also showed that the null hypothesis, H_0, (having unit roots) cannot be rejected for most of the variables in question for India and Pakistan. In the case of India, the log of total deposits ($LINdeposit_t$), total bank credit ($LINcredit_t$), the consumer price index ($LINCPI_t$) and the log of nominal GDP ($LINGDP_t$) as well as the growth rate of bank branches ($INBGRO_t$), and deposit interest rates ($INDEPOINT_t$) all are non-stationary in level form in cases both with and without time trend.

It is shown in the ADF unit root test result that all these variables were stationary in the first difference, which means that they are integrated of order one, I(1), in level forms. For Pakistan, we have also observed that the same variables, i.e. $LPAKdeposit_t$, $LPAKcredit_t$, $LPAKCPI_t$ and $PAKDEPOINT_t$ are all non-stationary in level form in cases both with and without time trend. A single exception is the variable $LPAKGDP_t$,, which is seen to be non-stationary in the first difference form in cases both with and without time trend, but when we applied the PP test that variable was shown to be stationary in the first difference form (see figures in parentheses).

The immediate implications following on from the unit root tests of TS data set are that any dynamic specification of the model in the levels of the series (such as the partial-adjustment model, frequently found in various literature) is likely to be inappropriate, and may be plagued by the problem of spurious regression. However, we may be guided towards a vector autoregressive model if the series of the model are co-integrated. Accordingly, the next step is to establish a co-integrating relationship between these non-stationary variables in the model.

5.2.3 Concept of Co-integrating Relationship and Long-Run Behavior of the Determinants of Deposit Behavior in Bangladesh

Engle and Granger (1987) have pointed out that a VAR estimated with different data will be incorrectly specified if the variables are co-integrated and the co-integrating relationship is ignored. So, after the confirmation from the unit root test (above) that all of the variables of interest are having unit roots and also after determining their order of integration which were one, I(1), we have moved forward to test for co-integration. The idea of co-integration is to determine if the stochastic trends in all the variables that contain unit roots (and have same order of integration) have long-run co-integrating relationship among them. Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series (which have same order of integration) may be stationary. That is, a set of non-stationary variables which (must) have same order of integration is said to be co-integrated if a linear combination of their individual integrated series, which are I(*d*), is stationary. If such a stationary linear combination exists, the non-stationary TS are said to be co-integrated. The stationary linear combination is called the co-integrating equation and may be interpreted as a long-run equilibrium relationship among the variables. In the original Engle and Granger approach to co-integration it is established that if the μ_t,s (variances) of a series are stationary, differences between the x_t series ultimately die out and the variables x_t are thought to exists in a long run balance.

In order to test whether there exists co-integrating relationships between non-stationary variables in the model we applied the Johansen (1988, 1991 and 1995) and Johansen and Juselius (1990, 1992) multivariate co-integrating methodology which jointly determine empirically the number of *r* (maximum *k-1*) co-integrating vectors from a vector of *k* endogenous variables in the model along with coefficients of the variables and the adjustment parameters. The Johansen procedure is based on the technique of reduced rank regression where *r* is the rank of the original vector of variables with order *k x r*[3].

5.2.4 *Estimates of Co-integrating Relations between Different Types of Deposit and Their Various Determinants: An Analysis of the Results*

In our empirical estimation the Johansen procedure is applied to a fourth order VAR (with the maximum lags four) to test for co-integration in seven sets of deposit equation for Bangladesh, one for India and one for Pakistan. In our deterministic trend component specification in co-integrating equations we choose case-3 (linear trend assumption), in which we assumed that the level series of endogenous variables have linear deterministic trends but the co-integrating equations have only intercepts (constants). This choice is based on our experience from the unit root tests which have shown that the critical values of ADF Statistics for all the variables were improving when we consider a time trend and also they are stationary in first difference (integrated of order one)[4]. Again, we observed that inclusion of time trend in the VAR did not make any significant effect on the value of trace statistics or maximum eigenvalue statistics in determining the co-integrating relationships.

We have estimated seven different co-integrating relationships for seven types of deposit model for the Bangladesh case, as below:[5]

Cointe. Eq.-1: Ltdeposit = $\alpha_{11} y_t + \alpha_{12} DEPOINT_t + \alpha_{13} \Delta pt\text{-}1 + \alpha_{14} Lbbranch_t + \alpha_{15} Ltadvance_t + e_{t1}$

Cointe. Eq.-2: Lcrdeposit = $\alpha_{21} y_t + \alpha_{22} DEPOINT_t + \alpha_{23} \Delta p + \alpha_{24} Lbbranch_t + \alpha_{25} Ltadvance_t + e_{t2}$

Cointe. Eq.-3: Lfxdeposit = $\alpha_{31} y_t + \alpha_{32} FIXEDINT_t + \alpha_{33} \Delta pt\text{-}1 + \alpha_{34} Lbbranch_t + \alpha_{35} Ltadvance_t + e_{t3}$

Cointe. Eq.-4: Ltmdeposit = $\alpha_{41} y_t + \alpha_{42} FIXEDINT_t + \alpha_{43} \Delta pt\text{-}1 + \alpha_{44} Lbbranch_t + \alpha_{45} Ltadvance_t + e_{t4}$

Cointe. Eq.-5: Lddeposit = $\alpha_{51} y_t + \alpha_{52} DEPOINT_t + \alpha_{53} \Delta pt\text{-}1 + \alpha_{54} Lbbranch_t + \alpha_{55} Ltadvance_t + e_{t5}$

Cointe. Eq.-6: Lrrdeposit = $\alpha_{61} y_t + \alpha_{62} DEPOINT_t + \alpha_{63} \Delta p + \alpha_{64} Lbbranch_t + \alpha_{65} Lrradvance_t + e_{t6}$

Cointe. Eq.-7: Lurdeposit = $\alpha_{71} y_t + \alpha_{72} DEPOINT_t + \alpha_{73} \Delta pt\text{-}1 + \alpha_{74} Lbbranch_t + \alpha_{75} Luradvance_t + e_{t7}$

As we can see that in current deposit function and rural deposit function current rate of inflation (Δp) is considered in place of price expectation due to the fact that for current deposits, the depositors do not give much importance as it is for short duration. The same is true for rural deposits as for the rural people in such developing countries the price as a factor is not much importance in their deposit decision. In the case of fixed and time deposit function we use interest rates on fixed deposit in lieu of the general deposit interest rate which is its own rate of interest. In the case of rural and urban deposits, we applied the rural and urban advance/credit growth rate which is theoretically consistent.

The econometric estimation results of co-integration are presented in Table 2 (see annex). Our specification of various deposit behavior models for Bangladesh suggests that a co-integrating (or long-run) relationship is expected to be found between different types of deposit including aggregate deposit (such as $Ltdeposit_t$,, $Lcrdeposit_t$, $Lfxdeposit_t$, $Ltmdeposit_t$, $Lddeposit_t$, $Lrrdeposit_t$, and $Lurdeposit_t$) and the independent variables captured in our theoretical specification.

The order of integration tests indicate that focus should be the I(1) series for income, interest rates, expected rate of inflation, bank advances and the proxy variable of banking service spread. The estimation results (see annex) show that in all the seven deposit models the critical values of the maximal eigenvalue statistics and trace statistics easily (strongly) reject the null hypothesis of no (zero) co-integrating vector in favor of at least one co-integrating vector in each case at both the 1% and 5% levels of significance. These imply that there were long run equilibrium relationship or stationary relationships between different variables of interest in various deposit functions of the Bangladesh economy such as: (1) aggregate deposit ($Ltdeposit_t$) is significantly influenced by y_t, Δp_{t-1}, $DEPOINT_t$, $Lbbranch_t$ and $Ltadvance_t$; (2) current deposit ($Lcrdeposit_t$) is significantly influenced by y_t, Δp_t, $DEPOINT_t$, $Lbbranch_t$ and $Ltadvance_t$; (3) fixed deposit ($Lfxdeposit_t$,) is significantly influenced by y_t, Δp_{t-1}, $FIXEDINT_t$, $Lbbranch_t$ and $Ltadvance_t$; (4) time deposit ($Ltmdeposit_t$) is significantly influenced by y_t, Δp_{t-1}, $FIXEDINT_t$, $Lbbranch_t$ and $Ltadvance_t$; (5) demand deposit ($Lddeposit_t$) is significantly influenced by y_t, Δp_t, $DEPOINT_t$, $Lbbranch_t$ and $Ltadvance_t$; (6) rural deposit is significantly influenced by y_t, Δp_t, $DEPOINT_t$, $Lbbranch_t$ and rural bank credit ($Lrradvance_t$); and (7) urban deposit is significantly influenced by y_t, Δp_{t-1}, $DEPOINT_t$, $Lbbranch_t$ and urban bank credit ($Luradvance_t$);

In the case of both India and Pakistan, we have tested the co-integrating relationship for only the aggregate deposit behavior ($LINdeposi_t$) as data on different categories or types of deposit are not available[6]. The aggregate deposit functions for India and Pakistan are as follows:

Cointe. Eq.-8: $LINdeposi_t = \alpha_{11} LINGDP_t + \alpha_{12} INDEPOINT_t + \alpha_{13} LINCPI_t + \alpha_{14} INBGRO_t + \alpha_{15} LINbcredit_t + e_{t1}$

Cointe. Eq.-9: $LPAKdeposi_t = \alpha_{11} LPAKGDP_t + \alpha_{12} PAKDEPOINT_t + \alpha_{13} LPAKCPI_t + \alpha_{14} LPAKbcredit_t + e_{t2}$

The estimation result shows that the critical values of the maximal eigenvalue statistics and trace statistics easily (strongly) reject the null hypothesis of no (zero) co-integrating vector in favor of at least one co-integrating vector in each case at both the 1% and 5% levels of significance. In the case of India, the result implies that there was a long run equilibrium relationship or stationary relationships between aggregate deposits of India and the independent variables captured in our theoretical specification such as: log of GDP, log of CPI, log of bank credit and growth rate of bank branches and also deposit interest rate.

In the case of Pakistan, almost same co-integrating relationship has been established which shows that the aggregate deposit behavior of Pakistan (*LPAKdeposit*) have been significantly influenced by log of GDP, log of CPI, log of bank credit and also deposit interest rate. However, the variable of bank growth rate is not included in the co-integrating relationship due to lack of data.

From the co-integrating relationships as estimated for Bangladesh, India and Pakistan, we can conclude that almost same variables are responsible for influencing aggregate deposit in those countries. But the more disaggregated diagnosis of different types of deposit behavior in Bangladesh with the help of co-integrating relationships has shed light on the variability of factors influencing different categories of deposit behavior in Bangladesh.

In the next sub-section we will employ Innovation Accounting approach using a VAR to determine the relative contribution of different variables of interest (forecast error variance, FEV) in the variation of the deposit growth which is known as variance decomposition. Because of relatively strong evidence of presence of a unit root in each of variables and presence of co-integrating relationships among the variables, the VAR model is estimated in levels.

5.2.5 Concept of VAR Methodology and Application of Innovation Accounting Approach to Deposit Behavior in Bangladesh, India and Pakistan

Vector auto-regression (VAR) is an econometric technique for estimating and analyzing the interrelationships among multiple time series. It is essentially a system of reduced form dynamic linear equations in which each variable is expressed as a function of serially uncorrelated errors and an equal number of lags of all variables in the system[7]. Unlike structural models, all variables in the system become endogenous, and a VAR model therefore specifies a relatively unrestricted dynamic process.

The primary appeal of the VAR approach is that the model is free from structural restrictions of any particular model builder, yet under relatively weak conditions it provides a reduced form framework within which economically meaningful hypotheses can be tested (see Sims (1980), Fischer (1981)]. The VAR model assumes that the contemporaneous correlations of errors across equations are nonzero. Since there are no contemporaneous explanatory variables in the model, their error terms (also called *innovations*) provide a potential source of new information about the movements in a variable during the current period. Alternatively, the VAR can be expressed in a stacked form, in which X represents the vector of variables:

$$\mathbf{X_t = A + B(L)\,X_t} + \varepsilon_t$$

Where, $\mathbf{X_t}$ is a stationary stochastic process, $\mathbf{L}$ is the lag operator such that $\mathbf{LX_t = X_{t-1}}$, $\mathbf{B(L)}$ represents the polynomial of autoregressive parameters and consists of innovations.

For the above VAR equation system to exist, the roots of $det(\mathbf{I} - \mathbf{B}(z)) = 0$, have a modulus greater than 1 so as to ensure that $(\mathbf{I} - \mathbf{B}(z))$ is invertible.

In an equation of the VAR system, only lagged values of all explanatory variables and the error terms are included. This error term accounts for the fact that the sum of the explanatory variables does not explain the dependent variable exactly at each observation over the sample period being analyzed. There always remains some discrepancy or errors to be accounted for. Since the explanatory variables in a VAR model include lagged observations and no current observations, the error term captures the movements of the explanatory variables in the current period and thus adds new information to explain the movements of dependent variable. That is why in the VAR literature, the current disturbance term in the equation for a given dependent variable is called *innovation* for that variable in the current period. A time series of such innovations is associated with each variable in the VAR system. Estimates of the VAR system require a large number of observations because of the number of parameters to be estimated. When a constant is included in each equation, the number of parameter in each equation equals the number of variables in the system times the number of lags plus one. Accordingly, one must either limit the number of variables and /or limit the lags in the system to avoid the depletion of degrees of freedom ([see Litterman (1985), Sims (1980b)] for details concerning the approach which restricts the number of freely estimated parameter). The variables included in the model are mainly motivated by economic theory and the types of hypothesis to be conducted. The set of variables in the system is not based on prior statistical testing.

5.2.5-1 Interpretation of VAR Estimates

Individual coefficients estimated in a VAR are not very meaningful because of the problem of severe multi-collinearity among the lagged variables. One, therefore, infers interrelationships among the model variables from either Granger Causality tests [Granger (1969)], or Forecast Error Variance (FEV) decomposition (also called innovations accounting) following Sims. This paper employs the FEV decompositions to derive economic interpretations of the data following Sims (1980a, 1980b).

5.2.5-2 Innovations Accounting

Innovations accounting involves the decomposition of the FEV for each variable into components attributable to its own innovations and to shocks to other variables included in the model and this is accomplished by utilizing the moving average representation (MAR) of the VAR system as follows: $\mathbf{X_t = C_t + a(L)\, X_t} + \varepsilon_t$;

where, $E(\varepsilon_t) = 0$ and $E(\varepsilon_t \varepsilon_t) = W$ for $|k| = 0$; and also $E(\varepsilon_t \varepsilon_t) = 0$ for $|k| \neq 0$

Where $\mathbf{C_t}$ is the perfectly predictable component of $\mathbf{X_t}$ and the moving average coefficients $\mathbf{a(L)}$ at lag 0 is the identity matrix.

According to the Wold decomposition theorem, the vector of innovations "ε_t" is the forecast error of the auto-regression based on information available at time t-1 given that the roots of $\boldsymbol{a(z)}$ lie outside the unit circle.

The MAR expresses the current values of the dependent variables in terms of current and lagged values of the innovations in all variables of the system. In principle, an infinite number of lags are needed to obtain the entire MAR representation (to get the system convergent). If we use the variation of past innovations as the estimate of the variation of future innovations, it is possible to obtain an estimate of the forecast error variance. Hence, the word "variation" refers not only to the variance of each innovation series but to the contemporaneous co-variances among all pairs of innovations as well.

The FEV for a given variable is equal to a sum of terms in the variances and co-variances of all the innovation series. This variance accounting can be done for the forecast error of each variable for any forecast horizon. In this way, one can analyze the way in which the variances of each variable's innovations influences the movements (i,e, variation) in each of the variables in the system. In principle, the variance decomposition contains very important information because it shows which variables have relatively sizeable independent influence on other variables in the system.

5.2.5-3 The Problem of Contemporaneous Correlations

As a matter of practical importance, there is one aspect of FEV decomposition that may be problematic in interpreting the results. While by construction the innovations in any series are serially uncorrelated, they may be correlated contemporaneously. Therefore, it is not proper to interpret the effects of an innovation in a given variable, say, **x**, as deriving solely from e_x. Part of an innovation in **x** may be due to the contemporaneous influence of other innovations on the **x** innovations[8]. Because of these contemporaneous correlations, interpreting the coefficients of the VAR as the effects of a given innovation on a given variable at a given lag may often be misleading. The contemporaneous correlation links the innovations of the variables in a way that may prohibit further meaning of decomposition of the FEV.

To quantify the cumulative response of an element of $\mathbf{X}_t$ to an innovation, it is imperative that the components of 'ε_t' be orthogonal. The effect of the orthogonalization is to allocate the contemporaneous correlation of the innovations among them. The standard practice is to choose some particular ordering of the variables, motivated by economic theory, prior to orthogonalization. The most widely used orthogonalization procedure is the *Choleski factorization*. The procedure eliminates any contemporaneous correlation between a given innovation series and all those series which precede it in the chosen ordering. One consequence of the *Choleski factorization* is that a variable that is placed later in the ordering will be assigned a reduced importance in the decomposition. Thus the ordering of variables is crucial in interpreting the results of the decomposed FEVs (see Cooley and Leroy (1985)).

5.2.5-4 Exogeneity Tests for Dependent Variables of the Models

The variable whose exogeneity is to be examined is placed in the first position of the ordering in the Choleski decomposition scheme [see E-VIEWS 4 Manual, 2000]. In this ordering the variable is given the full benefit of the correlations of all other variables placed next to it in the sequence. Its own innovations and the contemporaneous correlation of the remaining variables now explain the FEV of the variable in the system. So if a significantly large proportion of the FEVs of the variable remain uncorrelated for, the variable is considered exogenous. We also computed the FEV by placing the variables in the last position of the ordering.

The estimated FEVs of the variables in the last position of the ordering are completely free of conditional correlations and hence, its own innovations and the effects of other variables only through the lag structure now account for its FEVs. Based on the proportion of FEVs explained by own innovations all of our seven types of deposit variables for Bangladesh, aggregate deposit for India and Pakistan can not be considered exogenous.

5.2.5-5 Specifying the Empirical VAR System

After inducing the stationarity in the selected variables, we next determine the appropriate set of variables and the optimal lag length to specify VAR model. Initially we have considered a set of six variables for empirical analysis. The economic rationale for choosing these variables was based on the arguments of the theoretical model as discussed earlier. However, a 6 variable VAR model is not empirically feasible given the serious degrees of freedom constraint, and the severity of multi-collinearity. As a result, interpretation of causal linkages will also be problematic and misleading.

Which variable or variables to be included in the VAR specification is an empirical question. Therefore, several alternatives of five variable VAR models were estimated in a multiple regression framework and the best model is judged based on a minimum standard error (SE) criterion. The next step is to determine the optimal lag length to specify the VAR model. We employed the widely used likelihood ratio test to determine the optimal lag length following Enders (1996) (see appendix for technical note of lag length selection).The testing was conducted at a step of 1-quarters up to a maximum of k=14 periods to reflect quarterly changes.

Our estimations show that lags beyond (1 5) periods are not statistically significant. We therefore conducted all hypothesis testing based on VAR(1 5) models.

5.2.5-6 Estimation Results of the VAR Analysis

To compute the FEVs we use intuitive economic reasoning for ordering the variables following Sims (1980a), Bernanke and Blinder (1992) among many others. The ordering of variables in the Choleski decomposition scheme follows a causal ordering. The variable, which is believed to be exogenous, is placed in the first position, then other variables follow in a sequence as if the next variable is caused by the one preceding it. The various types of deposit variable ($Ltdeposit_t$,, $Lcrdeposit_t$, $Lfxdeposit_t$, $Ltmdeposit_t$, $Lddeposit_t$, $Lrrdeposit_t$, *and* $Lurdeposit_t$) in our case are placed in the last position on the assumption that all other variables affect this variable. The following causal chain is used to estimate the FEV decompositions of the seven different types of deposit behaviour in Bangladesh economy:

(1)	Ltdeposit	y_t	$DEPOINT_t$	Δp_{t-1}	$Lbbranch_t$	$Ltadvance_t$
(2)	Lcrdeposit	y_t	$DEPOINT_t$	Δp	$Lbbranch_t$	$Ltadvance_t$
(3)	Lfxdeposit	y_t	$FIXEDINT_t$	Δp_{t-1}	$Lbbranch_t$	$Ltadvance_t$
(4)	Ltmdeposit	y_t	$FIXEDINT_t$	Δp_{t-1}	$Lbbranch_t$	$Ltadvance_t$
(5)	Lddeposit	y_t	$DEPOINT_t$	Δp_{t-1}	$Lbbranch_t$	$Ltadvance_t$
(6)	Lrrdeposit	y_t	$DEPOINT_t$	Δp	$Lbbranch_t$	$Lrradvance_t$
(7)	Lurdeposit	y_t	$DEPOINT_t$	Δp_{t-1}	$Lbbranch_t$	$Luradvance_t$

For India and Pakistan, we have considered the following two causal chains to estimate the FEV decompositions:

(8) $LINdeposit \quad LINGDP_t \quad INDEPOINT_t \quad LINCPI_t \quad INBGRO_t \quad LINbcredit_t$

(9) $LPAKdeposi_t \quad LPAKGDP_t \quad PAKDEPOINT_t \quad LPAKCPI_t \quad LPAKbcredit_t$

The estimated FEV decompositions presented in table-3 to9 for a forecast horizon of maximum 15 quarters periods are based on one unit shock (one standard deviation, SD) to the system. During the initial periods, the system experiences instabilities with large variation over the forecast horizons and the FEVs are not very meaningful. The effects of the shock evolve over time to attain a stable equilibrium and we can observe that in our empirical result the FEVs were being stabilized after 12 period forecast horizon.

The results in Tables 3 to 9 indicate that for seven different types of deposits the system attains stability at about 12 quarter periods where the decomposed FEVs changes very slowly indicating that the system is in its stable equilibrium at that forecast horizon.

The FEVs of **aggregate deposit growth** presented in Table 3, shows that at 14 period horizon growth of real GDP (yt) account for one third (32.60%) of the variance of aggregate deposit growth followed by growth of bank branches ($Lbbranch_t$) and deposit interest rate ($DEPOINT_t$) which account 26.60% and 14.25% respectively of the variance of aggregate deposit growth. Price expectation variable also plays important role (8.54%) in the variation of aggregate deposit growth. The role of growth of bank credit evidences relatively less important (5.37%). It is notable that the $Ltdeposit_t's$ own innovations accounts for only 10.07%.

The fact that aggregate deposit' s own innovations account for a small proportion of the FEV indicates that past growth of deposit is not an important determinant of current rate of aggregate deposit growth. It is to be pointed out that the most important determinant of aggregate deposit growth is found to be the y_t which is not surprising as it is consistent with the theoretical as well as empirical view point in the context of Bangladesh. The FEV decompositions results for **current deposit growth** ($Lcrdeposit_t$) in Table 4 show that the VAR system attains stability at about 12 quarter periods. At the 12 quarter period horizon, growth of real GDP still account for major portion of the variance of current deposit growth even at a much greater proportion (46.07%) followed by growth of bank branches ($Lbbranch_t$) and growth of bank credit ($Ladvance_t$). Unlike the case for aggregate deposit, for current deposit growth $Ladvance_t$ plays much important role as it accounts 17.12% of the variation. The reason is theoretically sound by the fact that a substantial proportion of business credit including working capital and medium term and long term credit to entrepreneurs would automatically transferred into deposit account for a time period due to time lag in the process of realizing different investment projects.

As before, the deposit interest rate accounts for an important proportion of variance (13.38%) of current deposit growth. The price expectation variable is seen as less important variable which explain only 5.01% of the FEV of speed of current deposit growth which is also considered to be consistent with reality as the purpose of current deposit is not to maximize real profit rate by asset substitution. The notable point that could be seen in the FEVs of current deposit growth is that $Lcrdeposit_t$'s own innovations account for only 1.00% of the variation which implies that past values of $Lcrdeposit_t$ has no impact in the variation of current $Lcrdeposit_t$.

The variance decompositions of **fixed deposit growth** ($Lfxdeposit_t$) are presented in Table 5. For $Lfxdeposit_t$ we can observe that interest rate on fixed deposit contributes most (almost two third) to the variation of fixed deposit growth (60.38%) followed by GDP growth variable. Another difference in the FEVs is that in the variation of $Lfxdeposit_t$ the innovations of bank branch growth has been playing almost ignorable role (2.37%) and the reason is that normally the urban population contribute lion's share of fixed deposit where bank branches are very large in number.

Price expectations would be expected to play an important role in the variation of fixed deposits which is absent in the result as it accounts only 3.58% of the variation of $Lfxdeposit_t$.. One reason may be the very high interest rate on fixed deposit that exists in Bangladesh and which is given maximum weight in the decision matrix of fixed depositors.

The FEVs estimates of **time deposit growth** ($Ltmdeposit_t$) have shown expected result from theoretical viewpoint in Table 6. The result shows that GDP growth rate is the most important variable which accounts 38.45% of FEV of $Ltmdeposit_{t,}$, followed by interest rate on fixed deposit (18.25%) and price expectation (14.91%). But the contribution of bank branch growth rate and $Ladvance_t$, are no less important (13.03% and 11.33% respectively). The FEVs estimates of demand deposit growth ($Lddeposit_t$) have also shown (Table 7) that GDP growth rate accounts major part of the variation (24.47%) of $Lddeposit_t$, followed by deposit interest rate (16.04%). The role of inflation rate is seen to be important (15.57%) in the variation of $Lddeposit_t$ and the contribution of $Ladvance_t$ is no less important (5.98%) than $Lbbranch_t$.

The estimates of FEV decompositions on deposit behavior conducted on area based deposit model are presented in Tables 8 and 9 and the FEV decompositions results (Table 8) for **rural deposit behavior** ($Lrrdeposit_t$) show that at 12 quarter period horizon the substantial part of the variance of $Lrrdeposit_t$ is explained by deposit interest rate (33.38%), followed by growth of real GDP (23.37%). The reason behind such strong role of interest rate in rural deposit behavior is that the richer segment of rural people is the major contributor of $Lrrdeposit_t$. They have a very big informal credit market where rate of interest is very high and they would not substitute their surplus (that invested in informal credit market) for deposit into bank unless the interest rate in the formal market (bank) is reasonably high. The third important variable is bank branch growth rate that accounts for 20.20% of the variance of $Lrrdeposit_t$. In fact, in the context of Bangladesh it is important because in the rural area the spread of bank branches is very limited and with the increase of $Lbbranch_t$ people would get greater access to make deposit with the bank.

The variable $Ladvance_t$ also contributes strongly in the variation of rural deposit growth. The FEVs estimates of urban deposit behavior ($Lurdeposit_t$) are presented in Table 9. For the variation of $Lurdeposit_t$ the contribution of GDP is shown to be most important (32.98%), followed by interest rate (22.63%).

The 3rd and 4th important variables are expected inflation and growth of bank credit (15.62% and 14.92% respectively) which jointly accounts for more than 30% of the variation of $Lurdeposit_t$. The most notable point in this FEV estimates is that the growth of bank branches accounts only 1.08% of the variation of $Lurdeposit_t$ which is again expected as in Bangladesh the bank branches are mostly located in the urban area. Furthermore, it is important to note that the $Ltdeposit_t$'s own innovations accounts for 12.76% which means past growth behavior of aggregate deposit is no less important as a determinant of current rate of aggregate deposit growth.

In the Indian case, variable nominal GDP ($LINGDP_t$) has exerted most substantial contribution in the variation of aggregate deposit growth in Table 10. About more than 56% of the variation in aggregate deposit growth is due to GDP growth as seen in the 12th year forecast horizon. The second and third important variables are bank credit growth rate ($LINbcredit_t$) and inflation rate ($LINCPI_t$) which explain more than 17% and 10% in the variation of aggregate deposit growth in India in the 12th year forecast horizon. Again, in the same forecast horizon, we can observe that also the variable bank growth rate and deposit interest rate contribute effectively say, more than 9% and 6% respectively in the variation of aggregate deposit growth of India. Relatively weak impact of deposit interest rate on deposit growth was observed in case of India due to the possible reason that such interest rate is not fully market determined or not flexible enough to respond market conditions. It is notable to observe that $LINdeposit_t$'s own innovations accounts for very negligible proportion (only 0.12%) which means past growth behavior of aggregate deposit has almost no contribution in influencing the current rate of aggregate deposit growth in India.

For Pakistan, we have seen a very different scenario in the sense that there the role of deposit interest rate (*PAKDEPOINT*) is very prominent which accounts almost 34% of the variation of aggregate deposit of Pakistan in the 12th year forecast horizon in Table 11.

Other three variables such as GDP growth rate ($LPAKGDP_t$), inflation rate ($LPAKCPI_t$) and bank credit growth rate ($LPAKbcredit_t$) have also exerted important influence say, about 14%, 14% and 16% respectively, in the variation of aggregate deposit of Pakistan in the same forecast horizon. Furthermore, it is to be noted that the $LPAKdeposit_t$'s own innovations accounts for as high as 22.76% which means past growth behavior of aggregate deposit in Pakistan has a substantial influence in the variation of current rate of aggregate deposit growth.

6. Concluding Remarks and Policy Implications

Deposit growth is among the variables that are most closely watched by the monetary authority in shaping correct monetary policy, as an economy's investment growth is directly related to it. One would naturally like to know which variables they should watch more closely in order to gain a clear picture of the variations in different types of deposit growth.

This paper has employed both the co-integration and the vector autoregression (VAR) techniques to identify the important macroeconomic variables that are believed to be responsible for the variation of seven different types of deposit growth behavior in Bangladesh and also identify the variables that contribute or exert an influence in the variation of aggregate deposit growth of India and Pakistan. Our FEVs analysis shows that, in the case of Bangladesh, the two variables - growth of real GDP and the interest rate on deposits - jointly account for the lion's share of the variance of deposit growth (around 50.0%-60.0%), irrespective of the definition of the different types of deposit, followed by the bank branch growth rate.

Similar scenarios were observed in the cases of India and Pakistan, though they differed slightly in that GDP growth accounts for the lion's share - almost 57% - in India, while in the context of Pakistan the deposit interest rate accounts for a relatively small share. However, it represents biggest share in its own context: about 34% in explaining deposit growth behavior. Expectations of inflation on the part of households and the growth of bank branches also appear to exert a reasonably strong influence as well, in the variance of different types of deposit growth in Bangladesh and also in the variance of aggregate deposit growth in India and Pakistan.

Moreover, our co-integration results support the view that different types of deposit growth in Bangladesh and aggregate deposit growth in India and Pakistan are invariably positively related with economic growth and interest rate on deposits, as well as having long-run equilibrium relationships with other variables like bank branch growth, households' expectations of inflation and the growth of bank credit. One of the more interesting findings of our study is that, unlike many previous studies, we observed that the deposit interest rate has a strong and statistically significant positive role in influencing different types of deposit growth behavior in Bangladesh and Pakistan, with a weaker role being played by the deposit interest rate in the Indian case.

In contrast to many studies in the past, in which empirical results show lower interest rate sensitivity to deposit growth, we found that the interest rate is highly significant and positively sensitive to co-integration results and also accounts for a reasonably good proportion of the variation of different types of deposit growth. There might be different reasons for such differences in empirical results between past and present studies in Bangladesh, India and Pakistan. One such reason might be that the present study uses a more comprehensive database, which captures three different phases of financial sector development in all three countries: the pre-reform period (1973-1982), the period of intensive reforms (1983-1992) and the post-reform period (1993-2002). Therefore, it could easily accommodate the more effective role of interest rates as interest rate liberalization intensified both in the period of intensive reforms and the post-reform period and it began to play an increasingly active role in influencing many important macroeconomic variables including deposit growth. Moreover, unlike many previous studies, it uses quarterly data which gives a large number of observations and also a large degree of freedom, both of which are very important for any robust econometric (or statistical) estimate.

Secondly, unlike many previous studies, the present study applied the co-integration technique and the VAR technique, which are relatively recent, efficient econometric techniques for achieving more accurate estimates of relationships between economic variables. In an era of instant communication and exposure to all available information about the economy, it is reasonable to expect that the higher rate of economic growth and financial development has strong implications for changes in the long-run economic behavior of people, related to their lending-borrowing preference, their asset substitution and hence, their influences on deposit growth; we have demonstrated its practicability in our empirical results. Based mainly on our empirical results, we can recommend the following policy guidelines in order to enhance deposit growth in the three countries studied:

(i) More active and timely reforms and policies should be implemented, in order to ensure that market forces will freely determine the rate of interest. Our empirical results suggest that the more the interest rate is driven by market forces, the more effective will be its impact in influencing various important macroeconomic variables, particularly deposit growth in those three countries.

(ii) A higher rate of banking service growth is generally reflected by a higher bank branch growth rate and it is also considered to be a direct indicator of financial development.

Our empirical results show that the bank branch growth rate has a very important role in influencing deposit growth rates, which implies that financial development has a strong influence on deposit growth in all three countries. Accordingly, governments should implement policies to increase the number of bank branches or increase per-employee productivity in order to spread banking services to the people.

(iii) In our empirical results, the growth of bank credit/advances has shown that it has an important role to play in influencing deposit growth rate behavior and, as such, the central bank could implement an expansionary monetary policy in order to increase the growth rate of bank credit/advances.

Easy credit policies, the relaxation of the security base of loans and advancements, the expansion of credit through the central bank discount window and the adaptation of policies to stabilize the call money rate are effective in increasing the growth rate of bank credit/advances, as well as in making the interest rate determination process more transparent and ensuring that it is determined by the market to a greater degree.

One of the main shortcomings of the present study is that, due to serious data shortages, we could neither apply quarterly data nor apply the disaggregated approach to various types of deposit growth behavior in the Indian and Pakistan cases. Accordingly, the future direction of the current study should concentrate more on that aspect so that a more detailed database and approach could be applied to identify different factors influencing different types of deposit growth behavior in India and Pakistan. This could in turn enable us to construct a more complete comparative picture of the phenomenon of deposit growth behavior in these three South Asian countries.

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Notes

[1] In constructing quarterly GDP, we have followed seasonal factors for variations in agricultural

production. We first categorized six major agricultural crops: three varieties of rice, plus wheat, tea and jute, whose production are heavily affected by seasonality. For example, in rice production we have three major harvesting periods: Aman rice (October-December); Boro rice (April-June); and Aus rice (July-September). The harvesting periods of the other three agricultural goods are: wheat (January-March), tea (July-December) and jute (July-September). There is very little seasonal variation in the case of other major sectoral output, i.e. industrial and service sector output, therefore such output is distributed equally over the four quarters of each year.

[2] Let an *AR(1)* process : $x_t = \rho x_{t-1} + By_t + u_t$ ———— (1)

Where y_t are optional exogenous variables which may consist of constant or a constant and trend, ρ and B are parameters to be estimated, and the u_t is the stochastic error term that follows some classical assumptions as : $E(u_t) = 0$, $Var(u_t) = \sigma^2$ and $Cov(u_t, u_{t-1}) = 0$ (white noise disturbances).

Now if $\rho = 1$, we say that the stochastic variable x_t has a unit root (case of simple DF). The ADF test is based on an estimate of the regression of the following general specification: eq. (2) which is an alternative (for general *p*th variables, *AR(p)*) form of above *AR(1)* process expressed in the first difference term of the variables, that is, $\Delta x_t = (x_t - x_{t-1})$ (for higher order serial correlation, the assumption of white noise disturbance is violated but is corrected parametrically in the ADF)

$$\Delta x_t = \alpha_0 + \alpha_1 t + \alpha_2 x_{t-1} + \sum_{t=0}^{p} \theta_p \Delta x_{t-p} + \varepsilon_t \qquad (2)$$

where Δ is the first difference operator, α_0 is the intercept (constant), t denotes a linear time trend (optional exogenous or deterministic variables) and α_1, α_2 and θ_i are the coefficients where $\alpha_2 = \rho_{-1}$.
The random variable ε_t is a normally distributed white noise error term

Using quarterly data, we find that by initially setting $p = 6$, all residual autocorrelation is captured.

In eq. (1) we test the null hypothesis that the series x_t have unit roots that is H_0 : $\alpha_2 = 0$ ($\rho = 1$) against the alternative H_1 : $\alpha_2 \neq 0$ is tested by comparing the calculated tau (τ)-ratio (severer than conventional t-ratio) of α_2 with critical values based on the simulations response surface in Mackinnon (1991 and 1996) which are essentially adjusted t-values.

[3] Intuitively, Johansen's method follows the VAR-based co-integration test. Consider a VAR of order *p* :

$x_t = A_1 x_{t-1} +$ - - - - - - - - - - - $+ A_p x_{t-p} + B_{yt} + \mu_t$ ——— (3)

where x_t is a *k*-vector of non-stationary I(1) variables, y_t is a *d*-vector of deterministic variables (such as a constant, or a constant and time trend etc.) and μ_t is a vector of errors (innovations). We can rewrite this VAR as (after taking first difference) :

$$\Delta x_t = \Pi x_{t-1} + \sum_{t=0}^{p-1} \Gamma_i \Delta x_{t-i} + By_t + \mu_t \qquad (4)$$

where $\Pi = \sum_{t=0}^{p} A_i - I$; and $\Gamma_i = \sum_{j=i+1}^{p} A_j$

Granger's representation theorem asserts that if the coefficient matrix Π has reduced rank $r < k$, then there exists α and β matrices with order *k x r* each with rank *r* such that $\Pi = \alpha\beta$ and $\beta^* x_t$ is I(0) ; *r* is the number of co-integrating relations (the rank) and each column of β is the co-integrating vector.

The elements of α are known as the adjustment parameters (as explained below) in the VEC model. Johansen's method is to estimate the Π matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank ($r < k$) of coefficient matrix Π.

[4] In the case of tests for co-integration the critical values for the tests statistics differ according to the number of variables, k, in the co-integrating regression as well as according to the assumptions regarding the intercept and the deterministic trend component (five different specifications are available).

[5] Why we have categorized total deposit into different components such as time versus demand, fixed versus current and urban versus rural and hence, estimated separately is explained in the Appendix A (see also Table A).

[6] Due to severe data shortages we could not use quarterly data for both India and Pakistan

[7] In the VAR system it is customary to treat each variable symmetrically. Let us consider a three variables VAR system:

$x_t = \alpha_{11} x_{t-1} + \alpha_{12} x_{t-2} + \beta_{11} y_{t-1} + \beta_{12} y_{t-2} + \gamma_{11} z_{t-1} + \gamma_{12} z_{t-2} + e_{tx}$

$y_t = \alpha_{21} x_{t-1} + \alpha_{22} x_{t-2} + \beta_{21} y_{t-1} + \beta_{22} y_{t-2} + \gamma_{21} z_{t-1} + \gamma_{22} z_{t-2} + e_{ty}$

$z_t = \alpha_{31} x_{t-1} + \alpha_{32} x_{t-2} + \beta_{31} y_{t-1} + \beta_{32} y_{t-2} + \gamma_{31} z_{t-1} + \gamma_{32} z_{t-2} + e_{tz}$

where,

(i) { x_t } { y_t } { z_t } sequence are stationary
(ii) error terms e_{tx}, e_{ty} and e_{tz} are white noise with standard deviations of σ_x, σ_y and σ_z respectively
(iii) the error terms e_{tx}, e_{ty} and e_{tz} are uncorrelated
This system of equations constitutes a second order VAR system since the order of autoregression (lag length) is two.

[8] It is notable that a strong contemporaneous correlation generally(but not always)indicates the dynamic relationship between two variables that may follow over a longer time horizon. These correlations also indicate the direction of movements of the two correlated variables. In multiple time series modeling, the size of the correlations between two variable may provide some guidance as to their appropriateness for inclusion in the same model at the same time to avoid the problem of multicollinearity.

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Table 1: Unit Root Test: ADF Test Statistics (Period 1973-2002)

Variables	Variables in Levels		Variables in First Differences	
	ADF Statistics (No time trend)	ADF Statistics (With time trend)	ADF Statistics (No time trend)	ADF Statistics (With time trend)
I	II	III	IV	V
y_t	-0.13	-4.83**(-3.31)	-5.72***	-5.69***
$LINGDP_t$	-0.11	-1.53	-3.61**	-3.65**
$LPAKGDP_t$	-1.89	-0.82	-1.76	-3.00
			(-3.70***)	(-3.73**)
$DEPOINT_t$	-1.60	-0.88	-9.38***	-9.58***
$FIXEDINT_t$	-1.96	-2.06	-4.49***	-4.62***
$INDEPOINT_t$	-1.37	-0.51	-3.96***	-5.73***
$PAKDEPOINT_t$	-2.35	-0.68	-3.18**	-4.04***
Δp_{t-1}	-0.30	-2.62	-4.42***	-4.42***
$LINCPI_t$	-0.47	-2.31	-6.07***	-6.08***
$LPAKCPI_t$	-0.01	-2.88	-3.18**	-4.18**
$Lbbranch_t$	-3.10**	-2.57	-1.80	-2.55
			(-9.49***)	(-10.55***)
$INBGRO_t$	-1.51	-3.20	-5.84***	-5.71***
$Ltadvance_t$	-2.82*	-1.15	-1.67	-3.52**
	(-2.40)		(-11.60***)	(-12.11***)
$LINbcredit_t$	-2.60	-0.22	-4.31***	-4.18***
$LPAKbcredit_t$	-2.52	-0.19	-4.01***	-6.33***
$Lrradvance_t$	-4.55***	-2.05	-2.63*	-4.80***
	(-0.88)		(-9.65***)	
$Luradvance_t$	-1.38	-1.24	-4.08***	-4.25***
$Ltdeposit_t$	-1.79	-0.75	-3.60***	-4.01**
$LINdeposit_t$	-2.05	-1.84	-4.81***	-5.78***
$LPAKdeposit_t$	-1.89	-1.20	-4.05***	-5.16***
$Lcrdeposit_t$	-0.41	-2.26	-5.35***	-5.32***
$Lfxdeposit_t$	-2.97*	-1.63	-2.31	-3.40*
	(-1.70)		(-12.15***)	(-12.17***)
$Lrrdeposit_t$	-2.06	-1.94	-3.84**	-3.67**
$Lurdeposit_t$	-1.58	-1.25	-4.09***	-4.35***
$Lddeposit_t$	-0.75	-1.35	-9.90***	-9.88***
$Ltmdeposit_t$	-3.06*	-1.08	-1.74	-3.88**
			(-17.59***)	(-20.99***)

Notes : (a) The definition of Variables are the same as in the text. All lower case variables are in log form
(b) Optimal lag lengths for autocorrelation correction is determined by the Akaike Information Criterion (AIC)
(c) *, **, and *** indicates significance at 10%, 5%, and 1% level respectively
(d) Values in the 2nd, 3rd, fourth and fifth columns represent the t-values of the Augmented Dickey-Fuller (ADF) Statistics, with critical values based on the response surface in MacKinnon (1991).
(e) Each Regression in columns 3rd and fifth contains a constant and a time trend variable and Regression in columns 2nd and fourth are estimated with constant and without time trend variable
(f) The figures in parentheses are the values of Phillips-Perron Test Statistics and are given only when the **PP**-Statistic values are differents from the values of ADF Test Statistics in identifying Unit Root case.

Table 2: Estimates of Cointegration Functions

Cointe. Eq.-1: Ltdeposit = $\alpha_{11} y_t + \alpha_{12} DEPOINT_t + \alpha_{13} \Delta p_{t-1} + \alpha_{14} Lbbranch_t + \alpha_{15} Ltadvance_t + e_{t1}$
Cointe. Eq.-2: Lcrdeposit = $\alpha_{21} y_t + \alpha_{12} DEPOINT_t + \alpha_{23} \Delta p + \alpha_{24} Lbbranch_t + \alpha_{25} Ltadvance_t + e_{t2}$
Cointe. Eq.-3: Lfxeposit = $\alpha_{31} y_t + \alpha_{12} FIXEDINT_t + \alpha_{33} \Delta p_{t-1} + \alpha_{34} Lbbranch_t + \alpha_{35} Ltadvance_t + e_{t3}$
Cointe. Eq.-4: Ltmdeposit = $\alpha_{41} y_t + \alpha_{12} FIXEDINT_t + \alpha_{43} \Delta p_{t-1} + \alpha_{44} Lbbranch_t + \alpha_{45} Ltadvance_t + e_{t4}$
Cointe. Eq.-5: Lddeposit = $\alpha_{51} y_t + \alpha_{12} DEPOINT_t + \alpha_{53} \Delta p_{t-1} + \alpha_{54} Lbbranch_t + \alpha_{55} Ltadvance_t + e_{t5}$
Cointe. Eq.-6: Lrrdeposit = $\alpha_{61} y_t + \alpha_{12} DEPOINT_t + \alpha_{63} \Delta p + \alpha_{64} Lbbranch_t + \alpha_{65} Lrradvance_t + e_{t6}$
Cointe. Eq.-7: Lurdeposit = $\alpha_{71} y_t + \alpha_{12} DEPOINT_t + \alpha_{73} \Delta p_{t-1} + \alpha_{74} Lbbranch_t + \alpha_{75} Luradvance_t + e_{t7}$

Cointe. Eq.-8: $LINdeposit = \alpha_{11} LINGDP_t + \alpha_{12} INDEPOINT_t + \alpha_{13} LINCPI_t + \alpha_{14} INBGRO_t + \alpha_{15} LINbcredit_t + e_{t1}$
Cointe. Eq.-9: $LPAKdeposit = \alpha_{11} LPAKGDP_t + \alpha_{12} PAKDEPOINT_t + \alpha_{13} LPAKCPI_t + \alpha_{14} LPAKbcredit_t + e_{t1}$

	Null Hypothesis :	r = 0	r ≤ 1
Cointegrating Equation-1:	Trace Statistics (Lambda):	264.6**(94.15)	113.9** (68.52)
Aggregate Deposit Function	Max. Eigenvalue Statistics:	150.6**(39.37)	52.47** (33.46)
Cointegrating Equation-2:	Trace Statistics (Lambda):	287.8**(94.15)	108.0** (68.52)
Current Deposit Function	Max. Eigenvalue Statistics:	179.9**(39.37)	45.56** (33.46)
Cointegrating Equation-3:	Trace Statistics (Lambda):	292.6**(94.15)	109.7** (68.52)
Fixed Deposit Function	Max. Eigenvalue Statistics:	182.9**(39.37)	49.38** (33.46)
Cointegrating Equation-4:	Trace Statistics (Lambda):	286.9**(94.15)	117.0** (68.52)
Time Deposit Function	Max. Eigenvalue Statistics:	170.0**(39.37)	54.47** (33.46)
Cointegrating Equation-5:	Trace Statistics (Lambda):	243.0**(94.15)	125.1** (68.52)
Demand Deposit Function	Max. Eigenvalue Statistics:	117.4**(39.37)	52.88** (33.46)
Cointegrating Equation-6:	Trace Statistics (Lambda):	295.3**(94.15)	112.3** (68.52)
Rural Deposit Function	Max. Eigenvalue Statistics:	183.1**(39.37)	45.90** (33.46)
Cointegrating Equation-7:	Trace Statistics (Lambda):	283.66**(94.15)	101.5** (68.52)
Urban Deposit Function	Max. Eigenvalue Statistics:	182.2**(39.37)	51.82** (33.46)
Cointegrating Equation-8:	Trace Statistics (Lambda):	154.3**(94.15)	102.3** (68.52)
Aggregate Deposit Function (India)	Max. Eigenvalue Statistics:	52.0**(39.37)	33.22** (33.46)
Cointegrating Equation-9:	Trace Statistics (Lambda):	110.6**(68.52)	56.62** (47.21)
Aggregate Deposit Function (Pakistan)	Max. Eigenvalue Statistics:	54.0**(33.46)	31.56** (27.07)

The figures in the parentheses are 95% critical values corresponding to specific Statistic. ** and * indicates significance at 1% and 5% level respectively.

Table 3: Variance Decomposition of **Aggregate Deposit** Behavior of Bangladesh Economy (standard error in parenthesis), based on VAR(1 5) and Ordering of Variables as in Column 1

	Forecast Horizon in Quarters					
Proportion Explained by	1-quarter	3-quarter	6-quarter	9-quarter	12-quarter	14-quarter
y_t	5.04	17.67	33.76	31.43	27.21	32.60
	(4.52)	(14.06)	(21.47)	(18.28)	(18.85)	(18.99)
$DEPOINT_t$	6.42	6.96	12.16	10.88	12.89	14.25
	(4.44)	(7.64)	(12.72)	(13.79)	(13.81)	(13.94)
Δp_{t-1}	2.23	18.14	13.29	9.91	10.54	9.97
	(2.53)	(11.37)	(11.90)	(11.25)	(12.29)	(12.21)
$Lbbranch_t$	46.58	34.71	27.06	34.82	34.86	26.60
	(6.67)	(11.10)	(12.87)	(13.46)	(12.69)	(13.00)
$Ladvance_t$	1.15	2.63	1.70	1.46	3.62	5.37
	(1.37)	(6.76)	(7.50)	(7.45)	(9.25)	(9.84)
$Laggdeposit_t$	38.59	19.91	12.04	11.51	10.90	10.07
	(6.50)	(7.09)	(5.93)	(6.14)	(6.58)	(6.99)

Notes: The symbols for the variables in column 1 are those explained in the footnote of Table 1. The standard errors of variance decompositions (VDC) are estimated using the Monte Carlo simulations described in the E-VIEWS manual. The estimates are based on 1000 random draws, which are made directly from the posterior distribution of the VAR coefficients [see Runkle (1987), Sims (1987)]. The usual two standard error (2SE) criterion is used to judge the statistical significance of an estimated VDC.

Table 4: Variance Decomposition of **Current Deposit** Behavior of Bangladesh Economy (standard error in parenthesis), based on VAR(1 5) and Ordering of Variables as in Column 1

	Forecast Horizon in Quarters					
Proportion Explained by	1-quarter	3-quarter	6-quarter	9-quarter	12-quarter	15-quarter
y_t	0.67	32.50	49.43	51.87	46.07	41.65
	(2.01)	(12.37)	(15.55)	(16.70)	(16.89)	(17.12)
$DEPOINT_t$	42.20	24.99	17.20	15.01	13.38	11.24
	(7.33)	(10.42)	(10.30)	(11.79)	(13.59)	(13.03)
$Lbbranch_t$	48.04	24.31	15.04	15.08	17.22	22.12
	(6.89)	(10.22)	(11.12)	(13.05)	(13.45)	(14.19)
$Ladvance_t$	2.05	11.82	11.69	11.06	17.12	18.84
	(0.79)	(13.69)	(11.30)	(13.40)	(12.76)	(14.60)
Δp_{t-1}	0.77	3.31	4.60	5.59	5.01	5.14
	(1.69)	(2.93)	(4.43)	(4.96)	(4.98)	(4.92)
$Lcrdeposit_t$	6.26	3.07	2.04	1.40	1.19	1.00
	(1.47)	(0.96)	(0.87)	(0.87)	(0.88)	(0.79)

Table 5: Variance Decomposition of **Fixed Deposit** Behavior of Bangladesh Economy (standard error in parenthesis), based on VAR(1 5) and Ordering of Variables as in Column 1

	Forecast Horizon in Quarters					
Proportion Explained by	1-quarter	3-quarter	6-quarter	9-quarter	12-quarter	15-quarter
y_t	13.62	8.65	6.27	12.84	21.47	24.16
	(6.07)	(11.36)	(14.68)	(19.48)	(19.60)	(20.10)
$FIXEDINT_t$	68.66	83.21	81.81	73.51	64.60	60.38
	(6.10)	(14.11)	(18.82)	(21.56)	(22.16)	(21.82)
$Ladvance_t$	12.06	3.48	7.16	7.20	7.35	7.22
	(2.59)	(5.36)	(8.59)	(9.14)	(9.12)	(9.09)
Δp_{t-1}	2.07	2.21	2.38	2.46	3.58	4.87
	(1.16)	(6.32)	(8.43)	(7.81)	(8.53)	(8.58)
$Lbbranch_t$	1.32	1.61	1.67	3.19	2.37	2.71
	(0.91)	(4.83)	(4.46)	(5.27)	(5.43)	(6.29)
$Lfxdeposit_t$	2.28	0.83	0.70	0.79	0.63	0.66
	(0.43)	(0.46)	(0.50)	(0.51)	(0.44)	(0.45)

Notes: The symbols for the variables in column 1 are those explained in the footnote of Table 1. The standard errors of variance decompositions (VDC) are estimated using the Monte Carlo simulations described in the E-VIEWS manual. The estimates are based on 1000 random draws, which are made directly from the posterior distribution of the VAR coefficients [see Runkle (1987), Sims (1987)]. The usual two standard error (2SE) criterion is used to judge the statistical significance of an estimated VDC.

Table 6: Variance Decomposition of **Time Deposit** Behavior of Bangladesh Economy (standard error in parenthesis), based on VAR(1 5) and Ordering of Variables as in Column 1

	Forecast Horizon in Quarters					
Proportion Explained by	1-quarter	3-quarter	6-quarter	9-quarter	12-quarter	14-quarter
y_t	36.13	19.98	45.05	38.02	38.45	37.48
	(7.65)	(8.59)	(17.20)	(13.64)	(13.66)	(13.22)
$FIXEDINT_t$	0.17	2.56	2.46	14.79	18.25	18.68
	(1.07)	(8.18)	(11.04)	(15.69)	(16.35)	(16.38)
$Lbbranch_t$	2.13	16.90	12.97	13.49	13.03	12.67
	(1.76)	(10.94)	(10.56)	(9.16)	(11.23)	(10.33)
$Ladvance_t$	0.23	9.49	9.60	9.43	11.33	11.24
	(0.59)	(6.89)	(5.79)	(6.49)	(6.81)	(7.25)
Δp_{t-1}	31.32	39.35	23.84	19.24	14.91	5.70
	(5.93)	(13.08)	(14.33)	(13.74)	(13.99)	(12.98)
$Ltdeposit_t$	30.03	11.71	6.08	5.02	4.03	4.22
	(4.77)	(5.22)	(4.74)	(4.51)	(4.74)	(5.33)

Table 7: Variance Decomposition of **Demand Deposit** Behavior of Bangladesh Economy (standard error in parenthesis), based on VAR(1 5) and Ordering of Variables as in Column 1

	Forecast Horizon in Quarters					
Proportion Explained by	1-quarter	3-quarter	6-quarter	9-quarter	12-quarter	15-quarter
y_t	9.62	10.68	15.61	26.63	24.47	27.21
	(6.49)	(7.62)	(8.53)	(8.43)	(8.77)	(8.14)
$DEPOINT_t$	11.69	12.70	30.56	18.09	16.04	20.16
	(5.20)	(7.86)	(11.54)	(10.39)	(11.38)	(10.16)
Δp_{t-1}	0.03	8.81	5.99	11.51	15.57	15.12
	(1.14)	(7.31)	(7.43)	(7.98)	(8.50)	(8.88)
$Ladvance_t$	27.81	27.38	15.64	11.72	12.49	12.58
	(6.43)	(8.31)	(5.72)	(5.27)	(5.43)	(5.77)
$Lbbranch_t$	0.44	2.90	6.28	7.40	5.98	7.15
	(1.35)	(5.87)	(8.29)	(10.27)	(10.43)	(12.45)
$Lddeposit_t$	50.42	37.52	25.92	24.65	25.45	17.78
	(7.39)	(9.71)	(10.01)	(11.64)	(13.05)	(13.87)

Notes: The symbols for the variables in column 1 are those explained in the footnote of Table 1. The standard errors of variance decompositions (VDC) are estimated using the Monte Carlo simulations described in the E-VIEWS manual. The estimates are based on 1000 random draws, which are made directly from the posterior distribution of the VAR coefficients [see Runkle (1987), Sims (1987)]. The usual two standard error (2SE) criterion is used to judge the statistical significance of an estimated VDC.

Table 8: Variance Decomposition of **Rural Area Deposit** Behavior of Bangladesh Economy (standard error in parenthesis), based on VAR(1 5) and Ordering of Variables as in Column 1

	Forecast Horizon in Quarters					
Proportion Explained by	1-quarter	3-quarter	6-quarter	9-quarter	12-quarter	15-quarter
y_t	4.85	3.34	7.50	21.53	23.37	21.39
	(3.96)	(6.42)	(8.05)	(10.59)	(10.53)	(11.21)
$DEPOINT_t$	2.80	14.79	42.68	34.40	33.38	29.17
	(2.77)	(44.79)	(16.93)	(16.93)	(18.04)	(17.84)
Δp_t	0.36	0.25	7.05	5.93	4.30	10.60
	(1.13)	(6.02)	(8.65)	(7.67)	(8.21)	(8.88)
$Lbbranch_t$	45.42	46.27	22.58	17.66	20.20	23.13
	(6.36)	(14.22)	(12.56)	(14.36)	(15.57)	(15.42)
$Lrradvance_t$	26.70	14.20	14.69	15.40	14.19	11.07
	(5.32)	(6.87)	(6.80)	(6.93)	(8.06)	(8.64)
$Lrrdeposit_t$	19.87	13.33	5.50	5.09	4.55	4.64
	(3.22)	(3.96)	(2.49)	(2.42)	(2.04)	(2.33)

Table 9: Variance Decomposition of **Urban Area Deposit** Behavior of Bangladesh Economy (standard error in parenthesis), based on VAR(1 5) and Ordering of Variables as in Column 1

	Forecast Horizon in Quarters					
Proportion Explained by	1-quarter	3-quarter	6-quarter	9-quarter	12-quarter	15-quarter
y_t	23.88	34.05	29.24	33.37	32.98	33.12
	(7.73)	(13.05)	(16.28)	(15.79)	(16.01)	(16.46)
$DEPOINT_t$	29.49	19.41	23.75	21.93	22.63	22.80
	(6.63)	(13.16)	(16.70)	(14.34)	(13.64)	(13.61)
Δp_{t-1}	14.45	18.16	16.84	15.14	15.62	16.17
	(4.70)	(8.19)	(9.50)	(8.97)	(9.06)	(9.88)
$Luradvance_t$	1.45	9.31	16.46	15.31	14.92	14.44
	(1.40)	(8.95)	(14.10)	(13.69)	(12.36)	(12.38)
$Lbbranch_t$	1.20	0.26	0.74	0.90	1.08	1.20
	(1.32)	(3.53)	(5.73)	(6.18)	(5.53)	(12.45)
$Lurdeposit_t$	29.53	18.80	12.97	13.35	12.76	12.28
	(4.65)	(6.76)	(5.34)	(5.43)	(4.96)	(4.76)

Notes: The symbols for the variables in column 1 are those explained in the footnote of Table 1. The standard errors of variance decompositions (VDC) are estimated using the Monte Carlo simulations described in the E-VIEWS manual. The estimates are based on 1000 random draws, which are made directly from the posterior distribution of the VAR coefficients [see Runkle (1987), Sims (1987)]. The usual two standard error (2SE) criterion is used to judge the statistical significance of an estimated VDC.

Table 10: Variance Decomposition of Aggregate Deposit Behavior of **Indian Economy** (standard error in parenthesis), based on VAR(1 5) and Ordering of Variables as in Column 1

	Forecast Horizon in Quarters					
Proportion Explained by	1-quarter	3-quarter	6-quarter	9-quarter	12-quarter	15-quarter
$LINNGDP_t$	26.02	19.47	67.52	73.93	56.32	61.48
	(15.05)	(18.88)	(22.32)	(21.15)	(20.92)	(21.22)
$LINbcredit_t$	1.81	32.56	21.36	10.08	17.34	14.98
	(1.48)	(13.37)	(14.81)	(14.55)	(14.36)	(14.93)
$LINCPI_t$	44.49	16.79	3.22	7.30	10.40	11.93
	(12.04)	(8.73)	(5.83)	(6.66)	(7.40)	(7.76)
$INBGRO_t$	19.40	8.44	2.62	6.16	9.41	7.41
	(12.43)	(10.35)	(6.30)	(7.18)	(7.97)	(8.35)
$INDEPOINT_t$	2.34	21.28	4.98	2.37	6.41	4.09
	(7.43)	(17.86)	(11.49)	(11.50)	(12.89)	(13.02)
$LINdeposit_t$	5.95	1.46	0.29	0.16	0.12	0.11
	(2.42)	(1.10)	(0.46)	(0.44)	(0.49)	(0.48)

Table 11: Variance Decomposition of Aggregate Deposit Behavior of **Pakistan Economy** (standard error in parenthesis), based on VAR(1 5) and Ordering of Variables as in Column 1

	Forecast Horizon in Quarters					
Proportion Explained by	1-quarter	3-quarter	6-quarter	9-quarter	12-quarter	15-quarter
$LPAKGDP_t$	0.52 (5.59)	11.60 (8.79)	18.30 (10.70)	16.16 (10.62)	13.46 (10.61)	12.29 (18.99)
$PAKDEPOINT_t$	1.06 (6.02)	7.63 (10.58)	14.04 (12.48)	25.58 (14.44)	33.48 (15.25)	36.58 (11.72)
$LPAKCPI_t$	6.63 (7.50)	7.24 (7.27)	11.38 (8.01)	14.07 (7.88)	14.28 (7.29)	14.10 (10.33)
$LPAKbcredit_t$	49.86 (12.80)	34.81 (12.29)	25.83 (10.98)	19.96 (10.56)	16.10 (10.46)	14.47 (17.61)
$LPAKdeposit_t$	41.93 (11.57)	38.72 (9.66)	30.45 (9.56)	24.24 (9.17)	22.67 (9.02)	22.55 (13.49)

Notes: The symbols for the variables in column 1 are those explained in the footnote of Table 1. The standard errors of variance decompositions (VDC) are estimated using the Monte Carlo simulations described in the E-VIEWS manual. The estimates are based on 1000 random draws, which are made directly from the posterior distribution of the VAR coefficients [see Runkle (1987), Sims (1987)]. The usual two standard error (2SE) criterion is used to judge the statistical significance of an estimated VDC.

Appendix A

Several key features of deposit behavior in Bangladesh are worth noting in order to understand more clearly why we were keen to search for and identify different sets of determinants of deposit behavior after categorizing them into different classes/types.

i) Firstly, in Bangladesh the highest concentration of deposits found in respect of a zero rate of interest (non-interest-bearing deposits) is in the category of current deposits, which accounts for about 13% of total deposits (see Table B).

ii) Within the category of demand deposits, there are both non-interest-bearing deposits (such as current deposits) and interest-bearing deposits (such as cash and call deposits and other deposits).

iii) Demand deposits comprise almost 23% of total deposits (simple period average, 1973-2002), of which current deposits account for 13% and other non-interest-bearing deposits (such as cash and call) account for almost 1%. So, almost 40% of demand deposits fall into the category of interest-bearing deposits such as saving deposits (22% of total saving deposits) and some other deposits. So, we were interested to observe two things within the category of demand deposit behavior: one is how, as a substitute of interest-bearing deposits, current deposits, which are totally non-interest-bearing deposits, behave with respect to interest rates. So, in the co-integration function of current deposits, the explanatory variable, DEPOINT, does not play the role of own rate of interest of current deposits; rather, it captures the substitution effect between interest-bearing and non-interest-bearing deposits.

iv) In the category of time deposits, which represent almost 77% of total deposits (simple period average, 1973-2002), fixed deposits account for about 42% (32% of total deposits) and saving deposits account for 32% (25% of total deposits). So, a reasonably large share of time deposits is in the category of other deposits (26% within the category of time deposits), which mostly consist of different deposits that are not significantly influenced by interest rates. In the latter category, there are government deposits, restricted deposits and other public deposits. So, by making separate estimates of the contribution of FIXEDINT in the co-integration function of fixed deposits, we wanted to see whether there is a substitution between fixed and saving deposits, or between fixed, saving and other deposits; otherwise it would not be possible to trace the substitution effect between different categories within the time deposit function.

Table A

year	Simple Growth Rate of Total Deposits	Simple Growth Rate of Time Deposits	Simple Growth Rate of Demand Deposits	Simple Growth Rate of Total Deposits (INDIA)	Simple Growth Rate of Deposits Total (Pakistan)
1973	18.54	36.40	5.11	15.47	26.15
1974	12.83	24.88	10.74	18.68	33.25
1975	6.14	7.77	22.92	29.36	14.16
1976	10.10	11.79	8.51	21.00	24.99
1977	29.67	39.02	11.63	24.03	15.98
1978	18.29	19.54	16.73	18.61	13.60
1979	31.18	34.71	26.67	15.97	15.33
1980	18.60	22.51	13.91	20.53	18.92
1981	26.24	42.06	31.88	17.91	27.48
1982	13.97	17.99	5.90	17.65	5.97
1983	29.63	28.67	31.77	17.15	16.61
1984	43.51	38.16	33.34	19.15	17.70
1985	29.02	30.33	25.85	19.05	15.83
1986	17.86	17.58	18.56	15.94	6.09
1987	18.22	22.67	7.13	19.71	12.36
1988	13.98	24.97	17.37	14.14	22.07
1989	17.65	19.87	8.07	14.47	26.00
1990	16.08	16.97	11.79	18.86	23.42
1991	11.95	11.75	12.94	18.93	15.52
1992	14.31	13.86	16.50	15.73	20.19
1993	10.64	10.88	9.51	19.58	18.17
1994	14.53	12.29	25.50	8.21	15.93
1995	15.21	15.27	15.01	20.27	12.34
1996	8.22	7.60	10.91	19.52	7.39
1997	11.65	13.55	34.93	19.74	19.90
1998	10.62	12.48	18.80	17.04	8.92
1999	13.88	14.50	10.70	17.52	13.88
2000	18.86	19.88	13.34	13.98	11.86
2001	17.20	18.12	11.99	12.20	14.20
2002	13.65	14.76	7.01	14.65	11.65

Table B (period average, 1971-2003)

Type f deposits	Share in total	Share in their own category
Time deposits	**77%**	
Fixed deposits	32%	42%
Saving deposits	25%	32%
Other deposits	20%	26%
Demand deposits	**23%**	
Current deposits	13%	56%
Saving deposits	5%	22%
Other deposits	5%	22%

Source: Bangladesh Bank Bulletine (quarterly, different issues, period 1973-2002)

Appendix B

Technical Notes on Lag Lengths Selection

We have employed the widely used likelihood ratio test to determine the optimal lag length following Enders (1996). The procedure involves the following steps:
Estimate a VAR with the longest lag length feasible, given the degrees of freedom considerations. For example, with quarterly data one might start with a lag length of 18 quarters [denoted by **VAR(18)**] based on the prior notion that 18 quarters is sufficiently long to capture the dynamics of the system. Save the variance/covariance matrix of the residuals as Σ**(18)**. Now suppose one wants to determine whether 12 lags are appropriate. After all, restricting the model from 18 lags to 12 lags would reduce the number of estimated parameters by **6*n** in each equation. Now estimate the **VAR(12)** model over the same sample period, obtain and save again the variance/covariance matrix of the residuals as Σ**(12)**. Note that Σ**(12)** pertains to a system of **n** equations with **6*n** restrictions in each equations for a total of $\mathbf{6*n^2}$ restrictions. Sims (1980) recommends using the Likelihood Ratio Test Statistic in the following form:

$$LR = (\text{T-c})\ (\ \log|\Sigma\mathbf{(8)}| - \log|\Sigma\mathbf{(12)}|)$$

Where T= number of usable observations, c = number of parameters estimated in each equation of the unrestricted system, and is the natural logarithm of the determinant of Σ**n**. In our example, c = 18n +1; since each equation of the unrestricted model has 18 lags for each variable plus an intercept term. The Statistic has the asymptotic χ^2 distribution with degrees of freedom equal to the number of restrictions in the system. If the restrictions of a reduced number of lags were not binding, we would expect $\log|\Sigma\mathbf{(18)}| = \log|\Sigma\mathbf{(12)}|$. If the estimated value of the LR statistic is larger than the critical value of χ^2 (say, at 10% level of significance) then reject the null hypothesis that **VAR(18)** is the appropriate model. On the other hand, if the estimated LR< χ^2 we would accept the null hypothesis that **VAR(18)** as the appropriate specification.
In summary, the procedure sequentially tests a lower order **VAR**(k-3) as a constrained model against a higher order unconstrained **VAR**(k). An adequate model with an optimal order of autoregression is determined when the **VAR**(k) cannot be rejected based on a 10% (or lower) marginal significance level of χ^2 statistic. The

estimated χ^2 statistic for VAR(9) against VAR(12) was found to be statistically significant at 0.000126. This is not surprising given that the minimum SE criterion indicated an optimal lag length of 12 periods in the velocity equation. An examination of the estimated MSE indicates a very similar lag length for other equations as well.