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Contents

Growth and Diversification of the Russian Economy in the Light of Input-Output Tables

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Abstract

This paper addresses the issues of measurement of Russia's dependence on oil and gas as well its attempts at diversification with a shift toward a technology-centered economy. It further develops Russia's input-output system to provide a better understanding of these issues. First, it clarifies the extent of the GDP of the mining (oil and gas) sector in Russia by modifying the original supply and use tables. Second, it provides an analysis of the diversification attempts through the development of light automobiles by extending the supply and use tables. Third, it presents an attempt at multisectoral growth accounting based on our estimations of capital stock, focusing on the capital and TFP (total factor productivity) contributions to growth.

KEYWORDS: Russia, oil dependence, diversification, input-output, growth accounting

1. Introduction

The importance of the Russian oil and gas industry to the Russian economy as well as to global energy markets is rather obvious when we look at the statistics on proved reserves and the foreign trade of oil and gas. Russia accounted for 13% of global crude oil exports and 27% of global pipeline gas exports in 2007. Internally also, the shares of oil and gas in the country's export and GDP in 2007 were 62.0% and 16.9%, respectively (the corresponding shares in 2005 were 61.6% and 19.5%, respectively). Excluding refined oil or products from oil processing, the shares of crude oil and gas in the country's exports and GDP were 47.2% and 12.9%, respectively (the corresponding shares in 2005 were 47.6% and 15.0%, respectively).[1]

However, when we look at GDP statistics compiled by Rosstat (the Federal State Statistics Service) based on the *System of National Accounts* (1993) and data supplied by enterprises, the country's dependence on oil and gas is less clear. The problem with the official Russian figures is that they are very low. The share of the oil and gas sector in the Russian GDP under the traditional industrial classification (*OKONKh*) is 7.8% in 2000 and 6.8% in 2003[2]. The share of the mining sector in the country's GDP under the new industrial classification (NACE v.1; *OKVED*) is still low, that is 10.2% in 2005 and 8.1% in 2008, as seen below. In this paper, we offer alternative figures for the better understanding of the specific characteristics of the Russian economy. Although our estimation following

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1 All figures are derived from BP (2009), Interstate Statistical Committee of the CIS (2007, 2008), Rosstat (www.gks.ru) and Bank of Russia (www.cbr.ru) data.

2 *OKONKh* (*Obshchesoyuzhnyy klassifikator otrasley narodnogo khozyaystva*; all-union classification of sectors of the national economy). *OKVED* (*Obshcherossiyskiy klassifikator vidov ekonomicheskoy deyatel'nosti*; all-Russia classification of economic activities). See Rosstat: *Otdel'nyye*…, 2004.

Kuboniwa et al. (2005) is preliminary, it is sufficient to pose an important problem that should be resolved with Rosstat's cooperation. Our attempt also provides the manufacturing sector's GDP not only at basic prices but also at producers' prices or market prices that may be useful for an international comparison of industrial structure.

As Gaddy (2004, p. 346) points out, Russia's oil and gas sector will continue, for the foreseeable future, to be the key to the country's economic growth. Nevertheless, the recent policy direction for reforming Russia's industrial structure should also be noted and studied. As is well known, the Russian government adopted a policy to target diversification away from heavy dependence on oil and gas. A hopeful factor for this diversification and modernization of the Russian economy would be further development of the auto-industry, including domestic production (assembly) of light automobiles (passenger cars) by foreign companies. This paper provides a preliminary observation of the Russian auto-industry using unpublished versions of input-output tables.

A variety of desirable applications of input-output tables are possible. Due to the lack of appropriate data, we confine ourselves here to an application of multi-sector data to growth accounting for the further development of our analyses of Russian optimal growth configurations for diversification.

2. How Large is the Mining Sector of Russia?

The official figure for the share of the oil and gas sector within Russian GDP for 1991-2003 can be derived only from the input-output tables for the corresponding years compiled by Rosstat. As stated above, the problem with the official Russian figures is that they are very low. When we add the share of the value added attributed to the trade and transportation sectors (as trade and transportation margins and net taxes on oil and gas) to the official figure, we obtain substantially different figures: 24.1% in 2000 and 19.8% in 2003. These figures are shown in Table 1, the updated version of Kuboniwa et al. (2005). If this is the case, the share of industry should be increased by some 10%, and the share of the trade sector should be reduced accordingly (here, we ignore net taxes on products). This outcome completely changes the structure of Russian GDP and indicates that the contribution of the oil and gas sector to Russian economic growth must be reconsidered.

The method employed is based on a modification of the input-output tables (i.e., supply and use tables), involving a change of the units of statistical observation from enterprises to enterprise groups. Large holdings in the oil and gas sector include the following types of enterprises: 1) producing enterprises that extract and process oil and gas; and (2) trading enterprises that sell the oil and gas on domestic and international markets. Both are independent legal entities that generate their own statistical reports. As the main activities of the first type comprise extraction, the value that they add is not large. The value added by the second type (sales) is considerably larger than that of the producing enterprises, because the gross revenue of foreign trading enterprises is the difference between international and domestic price levels. Thus, for example, in 2002 the average export price of gas was more than 11 times higher than the gas producers' price. Such considerable price differentials accounted for the main income of the country's largest and exclusive gas exporter (trading enterprise), Gazprom. These two types of enterprises are independent legal entities but both are completely controlled by Gazprom. The same situation is observed in Russian

Table 1 Value Added at Basic Prices
(percentage of total GDP at market prices; old sector classification)

Component	2000	2001	2002	2003
Industry	28.2	25.2	24.4	23.9
Oil and gas sector	7.8	6.7	6.6	6.8
Transportation and communications	8.0	8.5	8.4	8.1
Transportation margins of oil and gas	1.0	1.1	0.9	0.8
Trading & intermediary services	21.2	26.6	26.7	26.9
Trade margins of oil and gas	10.7	7.7	7.4	7.7
Net taxes on products	11.4	12.3	11.5	12.1
On oil and gas	4.6	5.0	4.1	4.5
Total contribution of oil and gas sector	24.1	20.5	19.0	19.8
Contribution excluding refined oil	18.7	15.9	14.5	15.1

Sources: Kuboniwa et al., 2005, p. 7; *Sistema*, 2005, 2006; and unpublished Rosstat data.
Notes: Total contribution of oil and gas implies value added of oil and gas at market prices.

oil majors, including Lukoil. Lukoil is registered as a trading and intermediary enterprise, while crude oil extraction enterprises, affiliations controlled by Lukoil, are registered as crude oil extraction enterprises. We integrated the two types of enterprises into enterprise groups. It should be noted that the resulting discrepancy can be traced to the sector's specific characteristics rather than to faulty methodological treatment by Rosstat. In Table 1 part of the pipeline transportation margins is added to the value added of oil and gas because gas pipeline transportation is monopolized by Gazprom and oil pipeline transportation is monopolized by Transneft which can be regarded as a part of the oil industry group.

Rosstat reorganized all its statistics by sector based on the new industrial classification corresponding to the international and European standard, NACE v. 1. The official input-output systems (supply and use tables: SUTs) for 2004 and 2005 were made public in the *National Accounts of Russia* (2007, 2008) in a highly aggregated format with only 15 sectors: sectors A to O in NACE. Extraction of crude oil and gas is integrated into the mining sector. Although the mining sector excludes oil processing and includes extraction of coal, ore and so on, the major part of the mining sector consists of crude oil and gas, key Russian products. Moreover the specific Russian characteristics have remained unchanged. In 2005 the average export price of gas (US$151 per 1,000$m^3$) was approximately 13 times higher than the gas producers' price (US$11.70 per 1,000$m^3$). In 2005 the average export price of crude oil (US$330 per ton; US$45.20 per barrel) was also approximately twice as high as the crude oil producers' price (US$170 per ton; US$23.30 per barrel) (Rosstat: *Tseny v Rossii*, 2008, pp. 138-139). These price differentials generate the trade margins of the mining sector for 2005. Therefore we made modifications to the SUTs for 2004 and 2005 with a method similar to Kuboniwa et al. (2005). We did not introduce any modification to transportation margins because data on oil and gas pipeline transportation margins are not available and coal transportation (by rail, etc.) margins, which cannot be attributed to the coal enterprise group, may occupy a large share of the transportation margins of mining.

By adding the component of the value added attributed to the trade sector (as trade margins and net taxes on mining products) to the official figure, we obtain the following figures: 17.9% in 2004 and 20.4% in 2005, which are twice as large as the official figures. Most of the net taxes on mining products are generated by export taxes on crude oil and gas products, which constitute the main sources of the stabilization fund of the Russian federal government. Official GDP statistics usually provide the value added at basic prices. However, trade margins and net taxes on products by sector can be derived only from the supply tables compiled by Rosstat.

The aforementioned method allows us to modify the matrix of outputs of the supply table so that sales, which support the marketing of the sector's products, are treated as secondary activities in the mining industry. Table 3 presents a fragment of the modified supply table for the year 2005.

The analysis of the structure of the sector's output presented in Table 3 indicates that the share of trading and intermediation services (which are essentially secondary types of activity or product) in the mining industry amounts to more than 30% of the industry's output. One half of this share is occupied by foreign trade activities. Although not shown here, the share of such services in the gas sector can be estimated to be several times higher than the output of the sector's main activity (i.e., extraction). From the perspective of the SNA (System of National Accounts) framework, such a modified output matrix may appear

Table 2 Value Added at Basic Prices (percentage of total GDP at market prices; new sector classification)

Component	2004	2005	2006	2007	2008
Industry	27.8	29.3	28.1	27.4	26.0
Mining sector	8.7	10.2	9.4	8.7	8.1
Trading & intermediary services	17.8	16.8	17.6	17.7	18.1
Trade margins of mining products	5.6	4.8			
Transportation and communications	9.5	8.9	8.5	8.3	8.2
Transportation margins of mining products	…	…			
Net taxes on products	12.7	14.2	14.6	14.0	15.1
On mining products	3.5	5.4			
Total contribution of mining sector	17.9	20.4			

Sources: Author's estimation based on SUTs for 2004-2005 (SNA Russia, 2007, 2008) and www.gks.ru.

Table 3 Fragment of the Modified Supply Table for 2005

Products and services	Official table		Modified table	
	Mining sector (industry)		Mining sector (industry)	
	Million rubles	% of total	Million rubles	% of total
Mining extraction products	2,885,715.2	90.2	2,885,715.2	60.1
Other industrial products	272,992.9	8.5	272,992.9	5.7
Trading & intermediary services	10,295.8	0.3	1,611,814.6	33.6
Foreign trade services			805,813	16.8
Transportation services	15,180.3	0.5	15,180.3	0.3
Export transport services				
Real estate services	15,901.2	0.5	15,901.2	0.3
Total	3,200,085.4	100.0	4,801,604.2	100.0

Sources: Author's estimation based on supply table for 2005 (SNA Russia, 2008) and unpublished Rosstat data.

peculiar. One should remember, however, that it does reflect the realities of the Russian economy.

After appropriate modifications of the supply table, we also made changes in the use table. Due to the lack of data on the structure of input consumed by the trade activities of the mining sector, we simply applied the overall value added ratio (value added to output) given in the original use table to calculations of the value added of trade activities related to the mining sector. Details of our estimation for 2004 and 2005 are shown in Table 4.

To examine the plausibility of our estimation, we applied a method to estimate the corresponding value added of the trade services of the oil and gas sector for 2000-2003. As indicated in Table 5, the differences between the estimates by Rosstat and the author are rather marginal.

All of the sectoral value added data compiled by Rosstat, whether SNA (GDP) statistics or input-output tables, are evaluated at basic prices, which exclude net taxes on products. To obtain the sectoral value added at market prices or sectoral GDP, net taxes on products should be allocated to each sector or industry in an appropriate manner. Taxes on exports of crude oil and gas are paid by the trading companies of crude oil and gas. Although we can allocate net taxes on mining products to the trade sector, we lose the information on the source products of the taxes. Employing our methodology, these problems are avoided. It should also be noted that most fixed capital investments for oil

Table 4 Estimation Method for 2004 and 2005

		2004	2005
All components at basic prices			
1 Trade margin of mining	Million rubles	1,472,953	1,611,815
2 Value added ratio of total trade sector		0.65056	0.65060
3 Value added ratio of trade of mining	Line 3 = Line 2	0.65056	0.65060
4 Value added of trade of mining	Million rubles	958,244	1,048,647
5 Value added of trade of mining	% of GDP	5.6	4.8

Sources: Author's estimation based on SUTs for 2004 and 2005 (SNA Russia, 2007, 2008).
Notes:
Line 1 is from the official supply table and Table 3 for 2004-2005.
Line 2 is calculated from the official use table for 2004-2005.
Line 3 makes the crucial assumption that Line 3 equals Line 2.
Line 4 is derived from (Line 1)*(Line 3).
Line 5 is derived from (Line 4)/(total GDP at market prices).

Table 5 Application of the Method Employed Here to Oil and Gas for 2000-2003. (Percentage of total GDP at market prices)

	Value added generated by trade of oil and gas at basic prices		Difference
	Table 1 (Rosstat)	Estimation method employed here	
2000	10.7	10.2	0.5
2001	7.7	7.7	0.0
2002	7.4	8.9	-1.5
2003	7.7	8.0	-0.3

Sources: Table 1 and author's calculations.

and gas extraction have been financed from profits and revenues from the foreign trade in crude oil and gas. A rational method to prevent losing the relationship among profits, investments (fixed capital) and production is also proposed here. Except for the mining and trade sectors, sectoral value added at market prices or sectoral GDP can be obtained by adding the transpose of a column vector of net taxes on products in a supply table to a row vector of sectoral value added at basic prices in a use table.

Table 6 displays the change in the structure of value added (in basic prices) across all industries of the Russian economy caused by the modification of input-output tables. The table also shows the results for the Russian GDP structure across all industries for 2005.

As is evident, reallocation of trade margins reduces the share of trade and intermediation activities in value added at basic prices from 19.6% to 13.9%. Sectoral allocation of net taxes on products further reduces the share of trade and intermediation activities in GDP to 12% which is much less than the corresponding shares of the mining and manufacturing sectors. Sectoral allocation of net taxes on products brings about increases in the GDP shares of mining as well as manufacturing, which amounts to the largest share, 23.3%.

Table 6 Value Added and GDP by Sector for 2005

		Official use table	Modified use tables	
	Sector (Industry)	% of value added at basic prices	% of value added at basic prices	% of GDP at market prices
A	Agriculture, hunting, and forestry	5.2	5.2	4.6
B	Fishing	0.4	0.4	0.3
C	Mining and quarrying	11.9	17.5	20.4
D	Manufacturing	18.8	18.8	23.3
E	Electricity, gas, and water supply	3.4	3.4	3.0
F	Construction	5.4	5.4	5.1
G	Wholesale and retail trade; repair of motor vehicles and household goods	19.6	13.9	12.0
H	Hotels and restaurants	0.9	0.9	1.0
I	Transport and communications	10.3	10.3	9.3
J	Financial intermediation	4.1	4.1	3.5
K	Real estate, leasing, and business activities	9.9	9.9	8.6
L	Public administration and defense; compulsory social security	5.1	5.1	4.4
M	Education	2.6	2.6	2.3
N	Health and social work	3.0	3.0	2.6
O	Other community, social, and personal services	1.7	1.7	1.6
	FISIM	-2.4	-2.4	-2.0
	Total value added (at basic prices)	100.0	100.0	
	GDP (at market prices)	-	-	100.0

Sources: SUTs for 2005 (SNA Russia, 2008) and author's calculations.

3. Contribution of the Mining Sector to Russian Economic Growth

The outcomes, shown in Table 6, completely change the structure of Russian GDP and suggest that the contribution of the mining sector to Russian economic growth should be reconsidered.

In the Russian growth calculations employing a chain index with an annual change of the base year, the growth contribution rate of a sector in year t is defined as “the value added share of the sector in year (*t*-1)” multiplied by “the growth rate of the sector in year *t*”. Therefore, an increase in the value added share of a sector in the previous year results in an increase in the growth contribution rate of the sector in the current year.

First, we consider the modification of nominal growth by sector for 2005 caused by changes in the minimal industrial structure. Using the official data, the nominal growth rates of the mining, manufacturing and trade sectors in 2005 were 48.9%, 30.8% and 20% respectively (see Table 7). The nominal growth rate of the trade sector was much less than the total nominal growth rate of 27.6%. The nominal growth rate of value added related to the mining trade showed a markedly low value of 9.4%. The nominal growth rate of net taxes on products was rather high at 42.6%. In particular, the nominal growth rate of net taxes on mining products showed a remarkably high value of 97%.

Employing the modified data, the nominal growth rates of the mining and manufacturing sectors became slightly less than those based on the official data, while the nominal growth rate of the trade sector became greater than that based on the official data. The contribution percentage of the mining sector was 8.2% which was approximately twice as high as that based on the official data at 4.3%. The contribution percentage of the manufacturing sector was 6.8%, which was much higher than that based on the official data at 4.9%. The contribution percentage of the trade sector was 3%, which was slightly lower than that based on the official data at 3.6%. Thus, the major sources of nominal GDP growth were the mining and manufacturing sectors.

Table 7 Modifications of Nominal Growth by Sector for 2005

	Official data at basic prices			Modified data at market prices		
	2004	2005		2004	2005	
	% GDP share	% growth rate	% growth contribution rate	% GDP share	% growth rate	% growth contribution rate
	a	b	a*b	c	d	c*d
Mining	8.7	48.9	4.3	17.9	45.9	8.2
Manufacturing	15.8	30.8	4.9	23.0	29.5	6.8
Trading & intermediary services	17.8	20.0	3.6	12.3	24.4	3.0
Trade for mining	5.6	9.4	0.5	-	-	-
Other sectors	44.9	21.1	9.5	46.8	20.5	9.6
Net taxes on products	12.7	42.6	5.4	-	-	-
On mining	3.5	97.0	3.4	-	-	-
On manufacturing	7.2	26.6	1.9	-	-	-
On trade	0.1	-47.4	-0.0	-	-	-
GDP at market prices	100.0	27.6	27.6	100.0	27.6	27.6

Sources: SUTs for 2004 and 2005 (SNA Russia, 2007, 2008) and author's calculations.

Table 8 Modifications of Real Growth by Sector for 2005 and 2006

Sector	2005	2006	2005	2006
	Growth rate (%)		Contribution rate (%)	
	Official data at basic prices			
Mining	0.5	-3.3	0.04	-0.3
Manufacturing	6.0	7.3	0.9	1.2
Trading & intermediary services	9.4	14.1	1.7	2.4
Other sectors			2.5	3.1
Net taxes on products	9.4	9.1	1.2	1.3
GDP at market prices	6.4	7.7	6.4	7.7
	Modified data at market (producers') prices			
Mining	2.3	-0.004	0.4	-0.001
Manufacturing	7.1	7.9	1.6	1.8
Trading & intermediary services	13.5	21.1	1.7	2.5
Other sectors			2.7	3.3
GDP	6.4	7.7	6.4	7.7

Sources: Author's calculations based on www.gks.ru and SUTs for 2004-2005.

Next we consider the modification of real growth by sector for 2005 caused by changes in the minimal industrial structure in the base year and in the coverage of the mining and trade sectors.

The growth rate of value added in the trade of mining products is not known. The growth rates of value added in trade sub-sectors should be based on their trade turnovers. Foreign trade turnovers or exports of crude oil and gas showed negative growth in real terms for 2005 and 2006 as shown below. There is no reason to apply the high growth rates in the trade sector in the official data to the growth in the trade of mining products. Therefore, we assumed that the growth rate of value added in the trade of mining products is equal to that of the value added in the mining sector in the official data.

This resulted in marked increases in the growth rates of the trade sector based on the modified data from 9.4% to 13.5% in 2005 and from 14.1% to 21.1% in 2006, because a large component (the value added of the trade for mining) with lower growth was removed from the original value added of the trade sector. The high growth rates of the trade sector may be largely due to the boom in the trade turnover of imported goods.

Unlike trade margins, sectoral growth rates of net taxes on products are uniform. The official total growth of net taxes on products was higher than the macro growth. Accordingly, the allocation of net taxes on products in the mining and manufacturing sectors makes the growth rates of these sectors higher than the values prior to modification.

We present the results in Table 8. Based on the modified data, the contribution percentages of the mining, manufacturing and trade sectors for 2005 were 0.4%, 1.6% and 1.7%, respectively. The corresponding percentages for 2006 were 0% (-0.001%), 1.8% and 2.5%, respectively. The contribution of the trade sector to Russian economic growth was the largest for 2005 and 2006, followed by that of the manufacturing sector. The contribution of the mining sector, including crude oil and gas, to Russian economic growth was almost non-existent.

Generally, according to the Russian GDP statistics, in real terms the net exports have not contributed to GDP growth. The real income growth in Russia prior to the Lehman

Table 9 Terms-of-Trade Effects and Growth of "Command GDP"

	2005	2006
	"Command GDP" growth (annual percentage change at previous year's prices)	
Mining sector	38.0	15.6
Total economy	12.9	10.7
Notation:	Data for calculations	
Exports of crude oil and gas (million US$)	114,812	146,089
Real growth rate of exports of crude oil and gas at previous year prices (%)	-0.5	-1.8
Real exports of crude oil and gas at previous year prices(million US$)	79,784	112,772
Export price index of crude oil and gas	1.439	1.295
Import price index of the country	0.970	1.056
Terms-of-trade effect of crude oil and gas (million US$)	38,522	25,525
Terms-of-trade effect of crude oil and gas (million rubles)	1,090,172	693,985

Sources: Author's calculations based on Table 8; use tables for 2004-2005; External Trade 2007, 2008; and www.gks.ru.

shock, however, seemed to have been much greater than the real GDP growth owing to the marked increase in the terms-of-trade effects (TT) arising from high oil prices. This gap in perception can be solved by employing the so called “command GDP”, which is defined as real GDP plus terms-of-trade effects (see Kuboniwa, 2007).

The terms-of-trade effect expressed in base-year prices can be defined as follows:

$$TT_r = (E_n - M_n)/P - (E_r - M_r) = M_r(1 - P_m/P) + E_r(P_e/P - 1)$$

$$E_r = E_n/P_e,\ M_r = M_n/P_m$$

where subscripts r and n denote the real and nominal terms, respectively; TT is the terms-of-trade effects, and E and M are the exports and imports, respectively; Pe and Pm are the export and import deflators, respectively; and P is a common deflator of exports and imports.

If we take $P = P_m$, then $TT_r = E_r(P_e/ P_m - 1)$.

We employ this result in our calculations with an assumption that the above macro relations are applicable to sectoral relations using a uniform macro deflator, namely the import price index. We consider only the crude oil and gas sector’s terms-of-trade effects. Table 9 is obtained by adding these effects to the GDP of the mining sector.

The growth rate of the command GDP of the mining sector amounted to 38% in 2005 and 15.6% in 2006. In this context, we can state that the contribution of the mining sector to Russian economic growth in real terms was extremely large for 2005 and 2006.

4. Diversification of the Russian Economy

The Russian economy is heavily reliant upon the mining sector including crude oil and natural gas. This situation will not change for the foreseeable future. Even so, the recent policy direction for reforming Russia’s industrial structure should also be noted and studied. As is well known, the Russian government has adopted a policy targeting diversification and thus moving away from heavy dependence on oil and gas.

Table 10 shows the government's target for long-term changes in Russian industrial structure. The government expects the GDP share of the oil and gas sector will show a decrease from 19.7% in 2006 to 15.6% in 2015 and 12.1% in 2020. In contrast, the GDP share of the "high-tech" industry is expected to show an increase from 10.5% in 2006 to 13.8% in 2015 and 18.9% in 2020. The government's figure of the GDP share of oil and gas in 2006 proves that the government employs our methodology, shown in Table 1. The government relied upon the increasing trend for manufacturing, including the machinery industry, in contrast to the decreasing trend for mining, including crude oil and gas for 2000-2007. Although the Russian government, in its long-term plan, did not provide feasible policy measures to realize its target, we can state that the auto-industry is expected to become a key factor for the diversification and modernization of the Russian economy.

Table 11 shows an international comparison of the auto-industry including all motor vehicles and auto-components. The GDP shares of the auto-industry in Japan (2000), the United States (2000), and Germany (2002), having the most advanced foreign-make cars,

Table 10 The Long Term Prospects for Changes in Russian Industrial Structure (% of total GDP at 2006 market prices)

Sector	2006 actual	2010	2015 forecast	2020
"High-tech"	10.5	11.2	13.8	18.9
Oil and gas	19.7	16.3	15.6	12.1
Resource materials	8.4	7.9	7.4	6.8
Transport	6.6	6.2	5.5	4.9
Trade	17.7	14.5	13.6	12.2
Others	37.1	44.0	43.9	45.1
GDP	100.0	100.0	100.0	100.0

Source: MER, 2007, p. 35.
Notes: The table shows the optimistic case (innovative case).

The " high-tech" sector or the "innovative" sector should consist of the machinery industry, science, information-communication technology, education, and healthcare. This is quite different from the Western terminology.

Table 11 An International Comparison of Auto-industries

Country	Year	% of GDP at market prices
Japan	2000	1.6
USA	2000	1.2
Germany	2002	3.1
Brazil	2005	2.0
China	2002	1.5
India	2003/2004	1.0
Russia	1987	2.4
	1995	0.9
	2004	1.2
	2005	1.0

Source: Author's estimation using input-output tables.
Notes:The GDPs of the auto-industries of all the countries are evaluated at market prices.
The Russian GDP for 1987 is an estimate by Kuboniwa and Ponomarenko.

were 1.6%, 1.2%, and 3.1%, respectively.

The table also shows the auto-industry's GDP share in the BRIC countries. The GDP shares of the auto-industry in Brazil (2005), Russia (2005), India (2003/2004), and China (2002) were 2.0%, 1.0%, 1.0%, and 1.5%, respectively. Brazil showed the largest share of the BRIC countries. The domestic production level of passenger cars in 2005 was 2 million (Brazil), 1.1 million (Russia), 1.3 million (India), and 3.1 million (China) in physical number (*Automotive Yearbook*, 2009). In 2002, China's passenger car production was 1.1 million. This suggests that Russia's position in the auto-industry was the lowest of all the BRIC countries in 2005. All the BRIC countries showed rapid development in the auto-industry in the 2000s before the global crisis. The auto-industry in China and India, with small and cheap cars, has continued its rapid growth after the Lehman shock, while only Russia has shown a rapid fall.

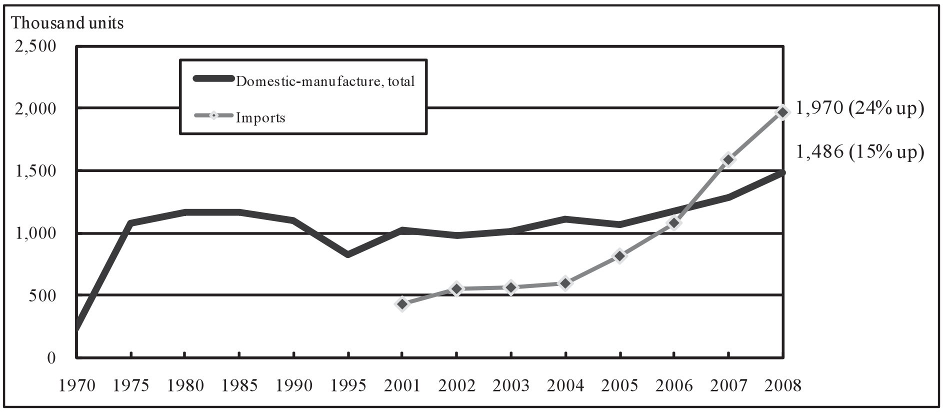
In 1987, in the Soviet era, the auto-industry's share of Russia's GDP was 2.4%, with a passenger car production of 1.2 million. This was achieved in a non-competitive environment. The Russian auto-industry's being challenged in a competitive environment started just before the global economic crisis. Now it is facing serious difficulties. However, Russia must develop the auto-industry if it really wants to achieve diversification of the economy. Russia has no other alternative for diversification and modernization in the medium term.

Figure 1 shows the Russian dynamics for passenger or light cars produced and imported in physical unit numbers. From this, we can report the following:

First, the boom in passenger or light car imports began in 2005 and continued until 2008. The number of car imports reached about 2 million in 2008, which was 3.3 times higher than the number imported in 2004. In particular, there was remarkably high growth of 47% in 2007. Although slowing down in the second half of 2008, there was high year-on-year growth at 24% in 2008 thanks to a boom in the first half of the year.

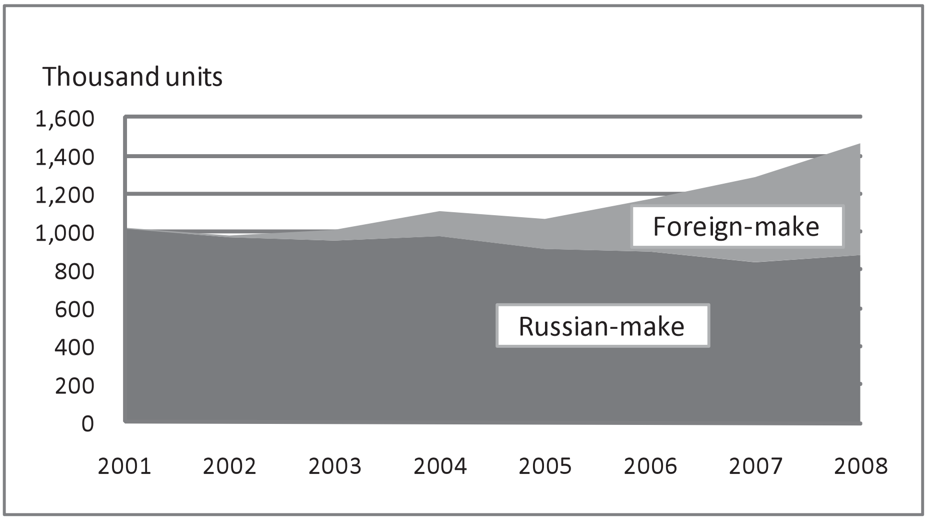
Second, the number of passenger or light cars produced in Russia, or domestically-manufactured cars, exceeded the Soviet peak-level in 2006 and showed marked increases of 10% in 2007 and 15% in 2008. It reached about 1.5 million vehicles, which was 1.34

Fig 1 Domestically-manufactured and Imported Cars in Russia: 1970-2008



Sources: Rosstat, Federal Customs Service.

Fig 2 Structural Changes in Domestic Car Production



Sources: Rosstat, Autostat.

times higher than the number produced in 2004.

Figure 2 shows the structural change in Russia's domestic light car production.

The boom in foreign-make cars made in Russia has been the major source for the increase in domestic light car production for the period 2001-2008. The number of foreign-make light cars made in Russia increased from 5,000 in 2001 to 591,000 in 2008, namely by more than 100 times. Their share in total domestic production increased from 0.5% in 2001 to 40% in 2008.

The Russian government, as well as most traditional Russian carmakers, clearly formed the perception that Russian-make cars cannot be competitive in terms of quality. Large Russian carmakers, except for AvtoVAZ producing Ladas, shifted to the assembly of foreign-make (foreign-brand) cars. Major foreign carmakers began to expand their assembly operations in Russia, making full use of preferential import duties on car components, based on the "industrial assembly" regime introduced in 2005. Thus, the boom in the assembly of foreign-make cars within Russia was brought about.

The industrial assembly regime assumes preferential duties on car component imports for (foreign or Russian) car assembly plants under the local condition that they should meet the requirement of a higher than 30% self-sufficiency rate of components within four-and-a-half years of their production start. Namely, makers enjoying the industrial assembly regime are required to switch from CKD (complete knock down) to SKD (semi-knock down) in a small number of years. A marked increase in the self-sufficiency rate is in the common interest of both the Russian government and foreign manufacturers. The foreign manufacturers need to raise the self-sufficiency rate to at least 70% to reduce their production costs. The government expects that this increase will bring about a radical development of the Russian industrial base, which has been the major bottleneck for Russian manufacturing.

The government expects foreign assembly makers to organize the production of auto-components in Russia by themselves. Unlike in the cases for China, India and Brazil, the Russian government had no industrial policy for the further development of the domestic production of components and parts except for the extension of the industrial assembly regime to foreign and Russian auto-part makers. The government should provide a more favorable investment environment for auto-part makers, including Russian SMEs and foreign giants.

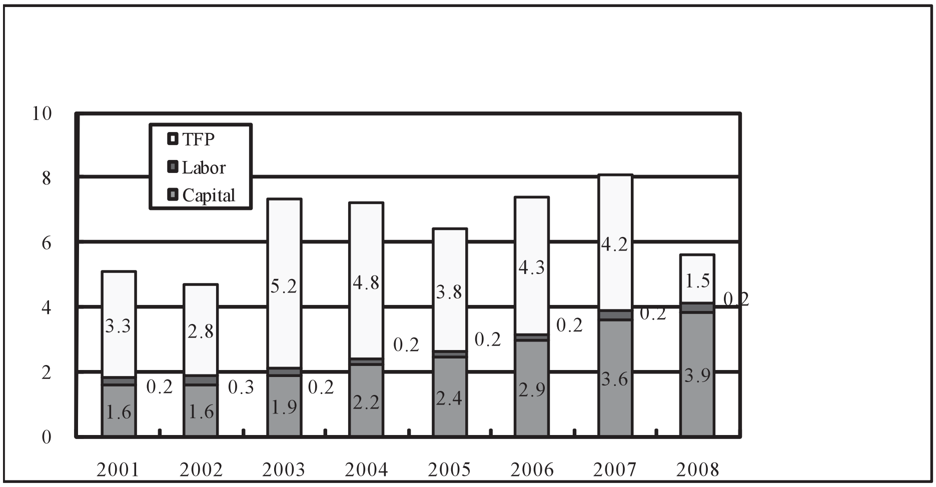
According to our rough simulation using the unpublished 2004 input-output tables (SUTs) with an explicitly separate auto-industry sector compiled by Rosstat, the Russian total GDP will show a 4-5% increase when the net final demand for automobiles becomes twice the level of 2004 via the reduction of car imports (import substitution) and/or some other reasons. In our simulation the self-sufficiency rate of auto-components is fixed at 30%. If the self-sufficiency rate of auto-components shows an increase to more than 70%, the expansion effect of the auto-industry on GDP would be much greater through the reduction of imports for the auto-industry. It should be noted here that both an assembled car and its components belong to the auto-industry sector. Thus, the expansion of domestic car production would provide a basis for the further development of the diversification of the Russian economy away from its dependence on the oil and gas sector.

5. Russian Growth Accounting

Figure 3 presents the author's calculations of macro growth accounting of the Russian economy for 2001-2008 based on our estimates of the capital stock and capital distribution ratio (70%) and the official data on GDP and employment (see Kuboniwa, 2008, 2009a). As is evident, the major source of Russian growth was TFP (total factor productivity) for 2001-2007, followed by the increment in capital, which showed steady growth. The TFP showed a marked decline in 2008 and further decline is expected in 2009.

For 2001-2007 the average growth rate for Russia was 6.6%. The average contributions

Fig 3 Growth Accounting (contribution rate; %)



Sources: www.gks.ru and author's estimations.

of capital, labor and TFP to this growth were 2.3%, 0.2% and 4.1%, respectively: that is, more than 60% of the growth was due to the TFP contribution. When we employ the official data of the growth rates of capital stock (www.gks.ru), the average contributions of capital, labor and TFP to growth amounted to 1.2%, 0.2%, and 5.2%, respectively. Approximately 80% of the growth was due to the TFP contribution. Smaller capital contributions induced greater TFP contributions. TFP incorporates all the components of technical progress due to capital replacement, management reforms, and so on.

Here we present the preliminary results of sectoral growth accounting. It should be noted that in the beginning of 2009 Rosstat made an upward revision of the manufacturing growth and a downward revision of the mining growth for 2005-2007.

Table 12 shows the results using the official growth rates of value added by sector. High increases in the capital stock of the mining sector did not induce its economic growth because they were not accompanied by any technical progress, which is shown by negative TFP contributions. Due to terms-of-trade effects the mining sector was able to increase capital stock, but this has not yet brought about the corresponding economic growth in domestic production.

In contrast, the high growth rates of the value added for the manufacturing sector were caused by capital increments as well as TFP contributions. Labor productivity also showed rapid growth. Regarding the electricity, gas and water supply sector, the better growth of the sector in 2006 was due to the TFP contribution as well as capital increments. In both 2005 and 2007 no contribution of the TFP was observed.

Table 13 shows the results using estimates of the sectoral GDP growth rates. The higher economic growth rates of the mining and manufacturing sectors resulted in improvements in the TFP contributions.

Table 14 displays the author's preliminary calculations of the growth accounting of the machinery sector for 2005-2007. The table shows that the rather high growth rates for the machinery sector were caused by high TFP contributions and improvements in labor productivity.

Table 12 Sectoral Growth Accounting of Russian Industry for 2005.2007

(%)

	Growth			Contribution			Growth	
	GDP	Capital	Labor	Capital	Labor	TFP	Labor productivity	Capital productivity
Mining								
2005	0.5	7.0	-3.4	4.9	-1.0	-3.4	3.9	-6.5
2006	-3.3	8.4	-0.8	5.8	-0.2	-8.9	-2.5	-11.7
2007	-2.7	9.8	-0.5	6.9	-0.1	-9.4	-2.2	-12.5
Manufacturing								
2005	6.0	4.1	-2.4	2.9	-0.7	3.8	8.4	1.9
2006	7.3	4.6	-1.3	3.2	-0.4	4.5	8.6	2.7
2007	8.1	6.1	0.2	4.2	0.1	3.8	7.9	2.0
Electricity, gas, and water supply								
2005	1.2	3.1	0.6	2.2	0.2	-1.2	0.6	-1.9
2006	5.7	3.1	0.6	2.2	0.2	3.4	5.1	2.6
2007	0.4	4.5	-1.1	3.1	-0.3	-2.4	1.5	-4.1

Source: Author's calculations.

Table 13 Sectoral Growth Accounting based on Estimated GDP for 2005-2006
(%)

	Growth			Contribution			Growth	
	GDP	Capital	Labor	Capital	Labor	TFP	Labor productivity	Capital productivity
Mining								
2005	2.3	7.0	-3.4	4.9	-1.0	-1.7	5.7	-4.8
2006	-0.004	8.4	-0.8	5.8	-0.2	-5.6	0.8	-8.4
Manufacturing								
2005	7.1	4.1	-2.4	2.9	-0.7	4.9	9.5	3.0
2006	7.9	4.6	-1.3	3.2	-0.4	5.0	9.1	3.3

Source: Author's calculations.

Table 14 Growth Accounting of the Machinery Industry
(%)

	Growth	Contribution			Growth
	GDP	Capital	Labor	TFP	Labor productivity
2005	10.4	0.4	-1.8	11.8	16.3
2006	8.6	1.3	-1.2	8.5	12.4
2007	15.4	2.1	0.7	12.6	13.1

Sources: Author's calculations.

6. Concluding Remarks

The Russian economy depends on the mining sector which includes crude oil and gas. The dependence on oil and gas has been much heavier than is reflected in the official data. Terms-of-trade effects caused by increases in oil prices had induced much higher growth than that shown by the official figures. Nevertheless, some development of diversification in the Russian economy was also found. It included an increase in the domestic production of foreign-make cars and better growth of manufacturing due to TFP contributions and capital increments.

After steady growth for 1999-2008, Russia entered a recession together with the rest of the world due to the global financial crisis. We now cannot expect positive terms-of-trade effects, such as oil windfalls, and improvements in the TFP of the manufacturing sectors. The terms-of-trade effects disappeared in 2008. In spite of rather high oil prices, around US$60 per barrel, the effects will not appear in 2009. The Russian economy will need more time to recover from its present deterioration.

Regarding the input-output database for Russia, the following points are noteworthy. First, more disaggregated SUTs, with 50 to 100 sectors, should be made public. Second, a time-series of SUTs in real terms should be prepared. Third, a compilation of capital stock vectors or matrices corresponding to SUTs would provide an appropriate database for the policymaking toward diversification of the Russian economy.

Whether “dreaming with Russia” will come true is still debatable. This paper provides only preliminary observations on this issue through the lens of input-output tables and growth accounting.

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Econometric Evaluation of the Fiscal Expansion and Stimulus Packages in Three Asian Countries and the United States

Taiyo Ozaki*

Abstract

This research is aimed at evaluating the effect of the recent unprecedented stimulus packages that have been carried out in China and the United States since 2008, and also the effects of fiscal expansion regarding China, Japan, the United States and the ROK.

The econometric model employed here was originally developed to analyze the changing properties of the trade relations between Asian countries and the United States, which is a rather small Asian Link Model involving China, Japan, the United States and the ROK with bilateral trade linkage models. This model is the expansion of the conventional econometric model in several directions. One objective is to further investigate changing bilateral trade patterns of a more flexible form among those four countries using a translog specification. The second objective is to use forward-looking variables to evaluate the anticipated expectations in new economic policy.

Keywords: East Asian Macroeconometric Model; forward-looking model; bilateral trade; translog model; stimulus package; multiplier

1. Introduction

During the last few years, the world economy has been hit by global financial shocks. A large amount of government spending on infrastructure and subsidies, called stimulus packages, has been put rapidly into place to rescue the sharply declining economy. Can stimulus packages, however, boost the economy in reality? If they are effective in the short term, then what is the size of the multiplier for GDP from the stimulus packages? There are several conflicting views in relation to this question. As for the multiplier, it ranges from "negative" to two or three. Our research focuses mainly on this topic. There is also another question, in that fiscal expansion will necessarily bring an increase in debt and cause crowding-out effects in the long term. The model employs a fixed-exchange-rate assumption, however, so we only evaluate the effects under the crowding-out through domestic absorption.

Regarding the model structure itself, the research is aimed at analyzing the properties of the Asian Link Model developed from 2005-2006, (see Ozaki, 2006), which consists of models for China, Japan, the United States and the ROK and a bilateral trade linkage model. The model is also designed to evaluate the recent fiscal stimulus packages.

This model has expanded conventional econometric models in several directions. One is to carry out further investigation of the changing bilateral trade patterns which include the four countries. Trade relations have been transformed so dramatically that it is

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inevitable that many countries assign a vertical structure to production across boundaries, and we must develop a new method which is more flexible and is able to evaluate properly the indirect role of third-country effects. Changes in trading patterns require the expressing of the explicit relationships in substitution or complementation effects between nations. We tried applying the translog function to the import share functions. Another direction is that the model uses forward-looking variables to evaluate the anticipated expectations in new economic policy. Recent neo-Keynesian econometric models usually adopt these formulations in the specification of consumption, and investment functions, et al. As we have no exact information about the future, however, the historical data in the forerunning period are assumed to be the future expected values and we estimate the parameters which give the minimum prediction errors; in this sense, the expectation is called "model-consistent" rather than "rational" when the model is simulated for a future period.

The model is annual and data are mainly obtained from OEF (Oxford Economic Forecasting, at present Oxford Economics) and the COMTRADE database, which covers the period from 1980-2005/2006. As the economic structure and the trade relationships have changed so greatly since the collapse of the bubble economy, however, the sample period used here is in reality somewhat reduced to 1990-2005 in many cases.

2. Model and Specifications

1) GDP definition

Each country model has a simple demand-side structure, generally as follows:

GDP = C+IF+GC+X-M

GDPV = CV+IFV+GCV+XV-MV

An affixed "V" denotes a nominal value. This is also the case for the following:

CV = PC*C/100

IFV = PIF*IF/100

GCV = PGC*GC/100

XV = PX*X/100

MV = PM*M/100

2) Consumption

The consumption function is formulated applying the Permanent Income Hypothesis, in which technically "model-consistent" expectations (sometimes confused with rational expectations) are assumed. This type of specification originally appeared in MULTIMOD, IMF (1998), in which forward-looking formulations were adopted.

The income constraint for a household is as follows;

$$W_{t+1} = (1 - t_w) YL_t - C_t + (1 + r) W_t$$

where W = wealth, t_w = tax rate, YL = household income, C = consumption, and r = interest rate.

We made the assumption of determining the consumption at the present time under the conditions maximizing the discounted total utility/income in the future:

$$\max_{C_t} E\left(\sum_{i=0}^{\infty} \left(\frac{1}{1+\delta} \right)^i u(C_{t+i}) \mid \Omega \right)$$

where u = utility function, δ = discount rate, and Ω = the available information set.

The expectation of future gain is approximately substituted for the expectation of the series for future income. There are many types of expectation such as a typical distributed time-lag model, but the most natural way to express future income is to induce forward-looking variables.

$$E\left(\sum_{i=0}^{\infty} \left(\frac{1}{1+\delta} \right)^i u(C_{t+i}) \mid \Omega \right) = E\left(\sum_{i=0}^{\infty} \left(\frac{1}{1+\delta} \right)^i YL_{t+i} \mid \Omega + W_t \right)$$

$$C_t = \left(\frac{\delta}{1+\delta} \right) E\left(\sum_{i=0}^{\infty} \left(\frac{1}{1+\delta} \right)^i (1-t_w) YL_{t+i} + W_t \right)$$

The final specification of the consumption function is given by:

$$C_t = c_0 + c_1 \left(\sum_{i=0}^{\infty} \left(\frac{1}{1+\delta} \right)^i (1-t_w) YL_{t+i} \right) + c_2 W_t$$

The brief notation using EViews is as follows:
C = F(PEDYV/PC*100 ΣPENW(+i)/PC(+i)/(1+RLG(+i)))
where PEDY = disposable income, PENW = wealth, and RLG = interest rate.

The table below shows the propensity for consumption of each country; it should be noted that Japan has a low propensity and the United States has a high propensity, exceeding 1.0 in the long term.

Table 1 Propensity for Consumption

	Income	Lag	Wealth
China	0.85 (*)	with lag	0.005
Japan	0.68 (*)	with lag	0.01
ROK	0.81 (*)	without lag	0.06
US	1.04 (*)	with lag	0.001

(*) propensity for consumption in the long term

PEDYV = PEWFP +PEOY-TY
where PEWFP, = wage income, PEOY, = property income, and TY = income tax.

SV = PEDYV-CV
PENW = PENW(-1)+SV
where SV = savings.

PEWFP = F(ER*ET)
where ER = earnings per capita, and ET = employment.

PEOY = F(RLB*PENW)
TY = F(PEDYV)

3) Investment

The ratio of the shadow value of capital to the unit of investment is known as the marginal Q, and this derives from the linear relationship between marginal Q and investment.

The marginal Q here is defined by the following formulation originally developed in Behr and Bellgardt (2002).

In the basic Q-model, firms are assumed to maximize the expected value of the sum of discounted profits:

$$\max_{\pi_t} E\left(\sum_{i=0}^{\infty}\left(\frac{1}{1+\delta}\right)^i \pi_{t+i} \mid \Omega\right)$$

where π = corporate profit.

We assume a Cobb-Douglas production function, $Y_t = AK_t^{\alpha} L_t^{\beta}$, and a profit function as follows:

$$\pi_t = pAK_t^{\alpha} L_t^{\beta} - w_t - q_t I_t$$

where p = output price, K = capital stock, L = labor, w = wage rate, q = unit cost of investment, and I = investment.

The marginal productivity of capital, MPK, is given by:

$$\frac{\partial \pi}{\partial K} = \frac{\partial Y}{\partial K} p + \frac{\partial p}{\partial Y}\frac{\partial Y}{\partial K} Y = \theta \frac{Yp}{K}$$

Here we presume $Yp \approx V$ (value added), therefore the estimate of θ is:

$$\hat{\theta} = \frac{\sum (r_i + d_i)}{\sum \frac{V_i}{K_i}}$$

The ratio of the shadow value of capital to the unit of investment is known as the marginal Q, and this derives from the linear relationship between the marginal Q and investment.

The marginal Q is defined by the next formulation:

$$Q_t = \sum_{i=1}^{\infty} E(MPK_i)\frac{(1+d_t)^i}{(1+r_t)^i} \approx \hat{\theta}\sum_{i=1}^{\infty}\frac{1}{(1+r_t)^i}\frac{V_i}{K_i}$$

As $d_t = \bar{d}$ is assumed, the effect of the depreciation is absorbed in $\hat{\theta}$. Lastly, we get the specification of the investment function:

$$\frac{I_t}{K_{t-1}} = \alpha_0 + \alpha_1\left(\sum_{i=1}^{\infty}\frac{1}{(1+r_t)^i}\frac{GDP_i}{K_i}\right) + \alpha_2\frac{Z_t}{K_{t-1}}$$

$$K_t = I_t + (1-d_t)K_{t-1}$$

where *Z* = additional explanatory variables such as the corporate operating surplus.

IF = IBUD +IFOR +ILON +IFF
where IBUD = investment from government funds, IFOR = investment via foreign capital, ILON = investment via private loans, and IFF = private corporate investment.

IFF/K(-1) = F(ΣGDP(i)/K(i)/(1+RLG(i)) Z(k)/K(-1))
where ΣGDP(i)/K(i)/(1+RLG(i)) = a proxy for marginal Q, and Z(k) = additional elements such as:
Z1 = COGTP
Z2 = RLB*PENW
Z3 = money supply, etc.

The estimated parameters are as follows:

Table 2 Investment Functions

	ΣGDP(i)/K(i)	*t*-value	Z(k)/K(-1)	*t*-value
China	0.22	3.29	43.1 (**)	4.05
Japan	0.20	2.18	21.5 (*)	2.48
ROK	0.13	0.94	50.1 (**)	3.46
US	0.43	3.71	27.0 (**)	1.27

(*) Z = money supply
(**) Z = corporate profit
K = IFF+K(-1)
China's foreign investment
IFOR = F(GDP(i)W(i)/W(j)GDP(j))

Foreign investment (FDI inflow) in China is substantially affected by Japan's GDP. A typical example is as follows:

log(IFOR) = −49.5−0.08*log(ER$/WWC$)+0.86*log(CN_GDP)+3.63*log(JP_GDP)

In this estimation, CN_GDP is not significant, and its elasticity is rather low.

4) Exports and Imports

Drastic changes in trading patterns have taken place since 1995. The role of China especially is rapidly becoming greater in exports to and imports from the rest of the world. Alongside this, the ROK has reinforced its dependency on China and the United States. In contrast, Japan increases its exports in the area of industrial supplies, in particular, and this causes the increase in imports of equipment and components from developing countries through FDI.

By way of an example, US imports have been growing, and if exports from Japan have diminished, the reduction must have been filled by third-country exports; therefore US imports are not determined solely by bilateral relationships. The role of trade substitution and complementation with third countries is becoming greater notwithstanding the conventional bilateral trade relationships.

Trade functions are specified by each of the combinations of trading partners (see Table 3). The row sum for Japan, for example, equals the total exports of Japan, with X$V denoting nominal exports in US dollars, and the column sum M$V consequently equals Japan's total imports.

The functions, as we present later, contain indirect relative price combinations to reflect the substitution effects with respect to third-party countries.

Table 3 Trading Partners: Exports and Imports

	China	Japan	US	ROK	Rest of world	World	
China	-	T(c,j)					
Japan	T(j,c)	-	T(j,u)	T(j,k)	T(j,r)	T(j,w)	X$V Total Exports
US		T(u,j)	-				
ROK		T(k,j)		-			
Rest of world		T(r,j)			T(r,r)		
World		T(w,j)					
		M$V Total Imports					

Consider a specific bilateral trade relationship between countries *i* and *j*. Of course country *i* has several options regarding trading partners importing and/or exporting goods. In the conventional model, the formulation of export T_{ij}, or import T_{ji} is typically a function of the demand of country *j* and the relative price, $\frac{p_i}{p_j}$. This model implicitly implies that the domestic demand of country *j* can be substituted by foreign goods from country *i*, but it does not describe explicitly how the change in the *i*-*j* relationship affects the *i*-*k* relationship.

To avoid this problem, we adopt the translog function formation to denote the *j*-*i* and *i*-*k* relationships.

We assume a linear homogeneous function:

$$M = f\left(M_1, M_2, \cdots\right)$$

where M = total real imports, and M_j = imports from country j, with j = 1,2,3,4 here.

To minimize the cost function of M, we use the translog function with a second-order approximation, and this is denoted by:

$$\ln MV = \ln\alpha_0 + \sum_{i=1}^{n}\alpha_i \ln P_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\gamma_{ij} \ln P_i P_j$$

$$+\alpha_M \ln M + \frac{1}{2}\gamma_{MM}\left(\ln M\right)^2 + \sum_{i=1}^{n}\gamma_{iM} \ln P_i \ln M$$

where MV = total cost, namely total imports in nominal terms.

Using Shephard's lemma:

$$\frac{\partial \ln MV}{\partial \ln P_i} = \frac{\partial MV}{\partial P_i}\frac{P_i}{MV} = \frac{P_i M_i}{MV} = S_i$$

$$= \alpha_i + \sum_{j=1}^{n}\gamma_{ij} \ln P_i + \gamma_{iM} \ln M$$

$$= \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln P_i + \gamma'_{iM} \ln GDP$$

and here we simply assume that *M = f(GDP)*.

The parameter constraints are as follows:

$$\sum_{i=1}^{n} \alpha_i = 1$$

$$\sum_{j=1}^{n} \gamma_{ij} = 0$$

$$\sum_{i=1}^{n} \gamma_{iM} = 0$$

The sum of column j of *T(i,j)* equals the total imports of country *j*. Each element reflects the export prices of the respective countries, which differ from each other, and form the composite import prices.

In reality, parameter constraints are so crucial that we only adopt $\sum \gamma_{ij} = 0$, and some calibration techniques to estimate parameters are applied: for example, we assume the demand elasticity of the importing country and the elasticity of the export price to be 0.1 and -0.01, respectively, if the estimation is not successfully carried out and it is needed.

Crude oil and natural gas are imported from the rest of the world and treated separately to be able to evaluate the effect of oil price changes: they are treated as exogenous, however.

5) Deriving Import Prices and Imports in Real Terms

In this model the export price is fixed and treated as an exogenous variable, while the import price is determined as the combination of the export prices of partner countries. For the purposes of illustration, we refer to the case for China:

CN_M$V = T(jpcn)$+T(krch)$+T(usch)$+T(rsch)$

CN_M$ = T(jpch)$/JP_PX$*100+T(krch)$/KR_PX$*100+T(usch)$/US_PX$(us)*100+XVrsch$

MVrsch$ = MOIL$+MGAS$+MCOAL$ + MrsCN_others$

CN_PM$ = CN_MV$/CN_M$*100

PM = F(CN_PM$*CN_RXD)

MV = F(CN_M$V*CN_RXD)

M = MV/PM*100

6) Tax and Financial Sector

Example: China

TAXES = TXAV+TXIV+TXTV+TY+TXOTH+TINT

where TXAV = tax on the agricultural sector, TXIV = tax on industry and commerce, TXTV = tariff on trade, TY = income tax, TXOTH = tax, miscellaneous, and TINT = tax on interest.

GREV = TAXES+GREVO

GEXP = GCV+GIV+GEOTH

GB = GBPRIM

= GREV-GEXP = -(GGDBTX) = GGDBT-GGDBT(-1)

7) Money Demand and Interest Rates

We chose the model with the monetary policy rule formulated originally by Clarida, Gali and Gertler (2000) and re-quoted in Cho and Moreno (2006). The theoretical model is as follows:

$$R_t = \alpha + \rho R_{t-1} + (1-\rho)[\beta E_t \hat{p}_{t+1} + \beta\, ygap] + \varepsilon_{MP}$$

R_1 is the combination of the past interest rate and the expected inflation rate and the deviation of output from the trend or the potential output. ε_{MP} is the monetary policy rules or the monetary shocks. The parameter α denotes the long-term reaction of the central bank to the expected inflation, and in addition β denotes the measure to evaluate the effects of the deviation of the output from the potential output, and here we adopt the money supply as a proxy instead of the difference in GDP.

The short-term interest rate

RSH = F(αRSH(-1) (1-α)PGDP(+1)/PGDPβMON/PGDP)

Table 4 Interest Rate Functions

	α	*t*-value	β	*t*-value
China	0.63	3.28	-0.99	-1.66
Japan	0.68	6.43	-1.50	-1.59
ROK	0.59	9.70	-3.51	-7.11
US	0.59	6.01	-2.16	-1.00

The long-term interest rate

RLG = F(αRLG(+1) (1-α)RLG(-1)βRSH)

8) Balance of Payments

RES$ = RES$(-1)+BCU$+BCAP$

BCU$ = X$V-M$V

X$V = nominal exports in dollars

M$V = nominal imports in dollars

BCAP$ = FDI$+NFDI$

9) Deflators and Price Indexes

Most deflator equations involve wage variables (earnings: ER) as a main explanatory variable. Wage growth is conventionally linked to the Phillips curve in which the difference in GDP is usually applied instead of the unemployment rate. This kind of specification seems to make the model unstable during simulation from 1990, however. Therefore, we adopt the formulation that labor productivity affects earnings in the long term.

$$\log ER_i = \alpha + \beta \log\left(\frac{GDP_t}{L_t}\right) + \gamma \log PC_{t-1}$$

This type of specification is rather conventional. We tried several types of specification in the context of the aggregate supply equation for new Keynesian macro models (Calvo, 1983; and Cho and Moreno, 2006); simulation results were not satisfactory, however.

PGDP = GDPV/GDP*100
PC = F(PC(-1) ER)
PIF = F(PM ER)
PGC = F(PC)
PX = exogenous
PM = determined by the trade sector, a combination of the prices of exporting countries

10) Labor
ET = F(GDP GDP(-1)/ET(-1))
U = LS-ET
URATE = U/LS*100
ET = employment
U = unemployment
LS = labor supply

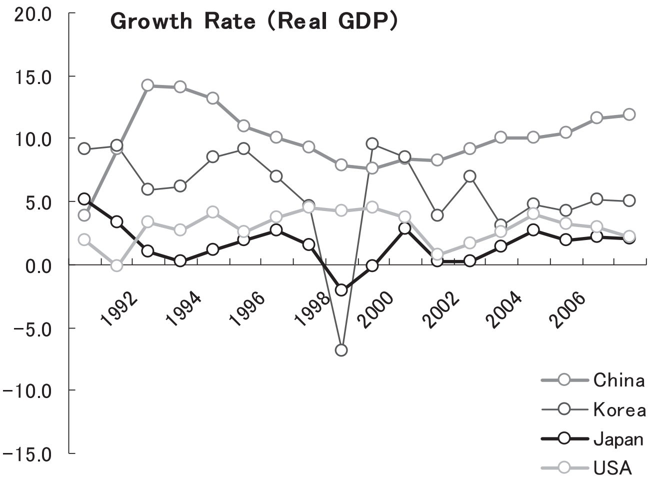
3. Testing the Model

To test and simulate the model, we need a slightly complicated procedure to deal with forward-looking variables, which was originally developed in Fair (1984) and sometimes called the "extended path method". This method calculates future expected values to determine the present value of endogenous variables; therefore, for example, future GDP affects present consumption because we usually anticipate policy changes in the future.

We carried out the final test from 1990 to 2005, and the results with GDP as the baseline for each country are presented below.

In the Asian models, it seems rather difficult to follow up on the deep trough during

Figure 1 The Growth Rates of the Four Countries



the 1997-1999 crisis.

The MAPEs (the Mean Absolute Percent Errors) regarding the principal endogenous variables for the period 2000-2005 are shown in the table below. The ROK model has somewhat larger errors for some key variables and needs to be improved, and the same is true for the results for unemployment.

Table 5 MAPEs

	GDP	GDPV	C	IF	X	M	PGDP	ET	U
China	1.5	4.4	2.0	4.5	1.3	8.1	3.0	2.3	47.8
Japan	1.9	3.3	0.5	5.2	5.0	1.1	1.4	0.7	13.7
USA	2.4	3.5	2.8	2.4	3.0	5.2	1.2	0.8	15.5
Korea	5.5	6.4	5.7	7.0	6.7	7.8	2.0	2.1	54.1

MAPE(%) 2000-2005

4. Simulation and Results

1) Simulation Scenarios

Case 1: *Fiscal expansion of China* = government investment +1% of real GDP, sustained shock

Case 2: *Fiscal expansion of Japan* = as above

Case 3: *Fiscal expansion of the US* = as above

Case 4: *Fiscal expansion of the ROK* = as above

Case 5: *China's expansion of government investment*

= +3.2% of nominal GDP for the 1st year, +5.2% for the second year, as a part of the recent big stimulus package

(Mizuho study, the maximum among similar estimates)

It was announced that fiscal expenditure will almost exceed 4,000 billion yuan in total, which amounts for almost 16.0% of nominal GDP as of 2007. However, several organizations such as the IMF (2009a), the Financial Times (15 November 2008) and the Mizuho Research Institute (Japan, 2009) have estimated that expenditure in reality may be restricted to a smaller amount than that announced. Some example estimates follow:

IMF: = 1,100 billion yuan over 3 years, 4.4% of nominal GDP (as of 2007)

Financial Times: = 1,180 billion yuan in 2 years (4.7%)

Mizuho Bank: = 2,100 billion yuan in 2 years (8.4%), 1st year = 800, 2nd year = 1,300 (3.2% and 5.2%, respectively) billion yuan

Case 6: *The US increase in government investment*

As a part of the recent big stimulus package, we assume an increase in investment by 0.742% of nominal GDP for the first year, 0.895% (second year), and 0.548% (third year) according to the proportions quoted by the IMF (2009a).

Here, we assume that the expenditure on infrastructure, state aid and education can be regarded as government investment, which amounts to US$314 billion in total, and is 2.18% of nominal GDP as of 2007. Therefore the figure used in the simulation is rather less than the total for the stimulus packages.

Table 6 IMF Estimates for Stimulus Packages
U.S.Stimulus Package
(in billions of dollars, CY basis)

	2009	2010	2011	Total
Total	283	259	121	663
(in percent of GDP)	2.0	1.8	0.8	4.6
Revenue measures	99	116	37	252
Individual income	37	80	32	149
Corporate income	57	32	-2	87
Other	5	4	7	16
Expenditure measures	184	143	84	411
Infrastructure and other	32	47	47	126
Safety nets	77	14	5	96
State aid and education	75	82	32	189

Source: U.S.CBO; Fund staff estimates.
Note: This table is quoted from the IMF (2009a)

Case 7: *US fiscal expansion* = a package of tax cuts and subsidies

Table 7 Tax Cuts as Percentage of Nominal GDP

	1st year	2nd year	3rd year
Income Tax cut	0.26	0.56	0.22
Corporate Tax cut	0.40	0.22	0.0
Safety Net	0.53	0.10	0.0

(*) Calculated from the IMF table above

Case 8: *Appreciation of the yuan (China)* = +10%, sustained shock is assumed
Case 9: *Appreciation of the yen (Japan)* = +10%, sustained shock is assumed

Lastly we quote the IMF summary on Stimulus Packages in Large Countries (IMF, 2009a):

Table 8 Summary of Stimulus Packages
Stimulus Packages in Large Countries
(in percent of GDP)

	2008	2009	2010	Total
Canada	0.0	1.5	1.3	2.7
China	0.4	2.0	2.0	4.4
France	0.0	0.7	0.7	1.3
Germany	0.0	1.5	2.0	3.4
India	0.0	0.5	…	0.5
Italy	0.0	0.2	0.1	0.3
Japan	0.4	1.4	0.4	2.2
U.K.	0.2	1.4	-0.1	1.5
U.S.	1.1	2.0	1.8	4.8
Average 1/	0.5	1.6	1.3	3.4

Source: Fund staff estimates
1/PPP GDP-weighted average.

2) The Multipliers of Government Investment

Cases 1 to 4 show the multipliers of fiscal expansion for the four countries. As we know, there is debate on the magnitude of the multipliers which range from “negative” to 2 or 3. On average, many studies report that a 1% increase in government investment has been found to increase GDP by close to 1%. See IMF (2009b), Taylor (2009), ESRI (Japan, Cabinet Office, 2008), Christiansen (2008), Botman and Laxton (2006), Perotti (2005), and Ban (2000, 2002). Our results are shown in the following table, in which multipliers affecting the countries themselves range from 1.04 to 1.49. Fiscal expansion in both Japan and the United States does not appear to have such a great effect on their own economies, but does on those of China and the ROK.

Comparing the United States and Japan, the United States is more dominant over the developing countries, whereas the role of Japan has recently diminished, but still has a large influence both on China and the ROK. It is notable that China’s expansion causes a 0.19% increase in the ROK’s GDP and the ROK has accelerated its dependency on China.

Table 9 Fiscal Expansion Multipliers (Peak Values)

Multiplier summary		Peak effect on GDP of:			
		China	Japan	US	ROK
Expansion in government investment of:	China	1.49	0.04	0.00	0.19
	Japan	0.08	1.16	0.01	0.16
	US	0.19	0.02	1.21	0.21
	ROK	0.01	0.01	0.00	1.04

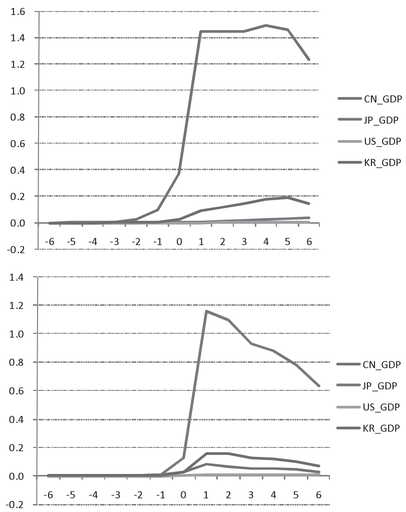
Dong He, Zhiwei Zhang and Wenlang Zhang (2009) estimate the Chinese multiplier to be around 1.1 in the medium term, as fiscal spending leads to higher household consumption and corporate investment over time. However, this seems rather low compared to other research considering the structural models of input-output frameworks.

Our results are shown in the graphs below:

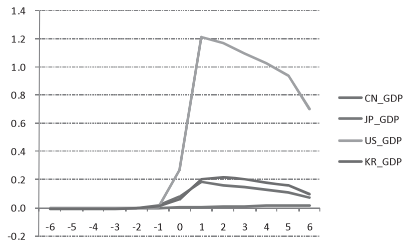
Figure 2 Fiscal Expansion Multipliers

China

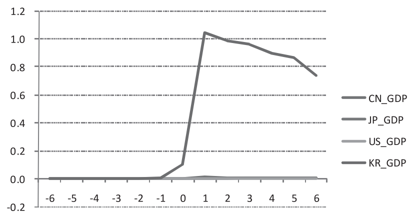
Japan



US



ROK



Regarding multipliers for Japan, Fumikazu Hida et al. (2009, ESRI) report the effect of government investment (1% of real GDP) to be 1.0 for the first year, which is a little lower than our result. In their paper they also argue that the effects of tax cuts will remain less than 60% of those in the case of increased investment, and the interest rate will decline in the short term.

John F Cogan, Tobias J Cwik and John B Taylor (2009) report on the multiplier for the US economy. It is in the range 1.4–1.5 at its peak, and declines rapidly to zero.

In general the multipliers become smaller for every nation, which reflects the lack of private-sector response and the shift to lower multiplier spending. As we have shown, the fiscal expansion multipliers range from 1.04 to 1.49, which depends on the ratio of investment to total demand, the structure of consumption and the import elasticity relative to GDP and how it raises interest rates in the long term. As for the ROK, the increase in GDP augments imports which tend to function to reduce the multiplier.

In the case of the ROK the multiplier is the lowest, which is due to the openness of the ROK economy, expanding leakages via trade channels.

China has a strong dependency on the United States, followed by Japan. At the same time, the ROK is increasing its dependency on China.

3) The Domestic Effects of Fiscal Expansion

Using the same simulation as above, we examined the domestic effects of fiscal expansion. As the scenario is designed to increase government investment, IF (investment) is necessarily the leading category for demand, whose multipliers range from 3 to 5. However, in the case of the ROK, government investment has some tendency to come round to support households and boost consumption.

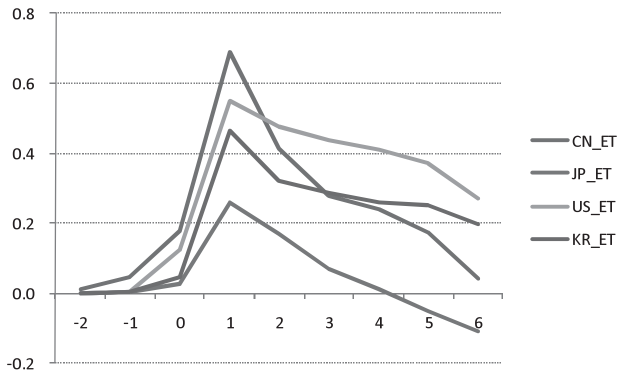
In every country, the fiscal expansion will bring an increase in price deflators by 0.2–0.4%. Among the four nations, Japan has the lowest increase in employment, and the New Deal in Japan will not do much toward increasing new employment.

Table 10 1-3 Year Average Effects of Fiscal Expansion (%)

	GDP	GDPV	C	IF	X	M	ET(Labor)	PGDP
China	1.44	1.70	0.38	3.87	0.00	0.87	0.46	0.25
Japan	1.06	1.28	0.42	3.40	0.01	0.83	0.16	0.22
US	1.16	1.38	0.25	5.24	0.00	0.40	0.49	0.22
Korea	1.00	1.40	0.51	3.37	0.00	0.71	0.36	0.40

The distinctive low effect on employment in Japan is shown in the figure below:

Figure 3 Effects on Employment



4) The Effects of Stimulus Packages

China's stimulus package

China's stimulus package has a great effect on its economy. It raises GDP by 5.88% and also boosts the ROK economy, which greatly depends on China's economy, by 0.63%. In the long term, however, the effects will slow to less than 1%.

Table 11 The Effects of China's Stimulus Package

	CN_GDP	JP_GDP	US_GDP	KR_GDP
-2	0.09	0.00	0.00	0.01
-1	0.34	0.00	0.00	0.04
0	1.33	0.00	0.00	0.14
1	5.24	0.01	0.01	0.51
2	5.88	0.01	0.01	0.63
3	-0.02	0.01	0.00	-0.02
4	0.38	0.01	0.00	0.04
5	0.42	0.01	0.00	0.07
6	0.30	0.01	0.00	0.04

This fiscal expansion will increase employment up to 2.47%. Excess employment, however, should be adjusted in the long term: it will fall to -2% within a few years. On the other hand, it is notable that the rise in the GDP deflator will remain less than 1%.

Figure 4 China's Stimulus Package

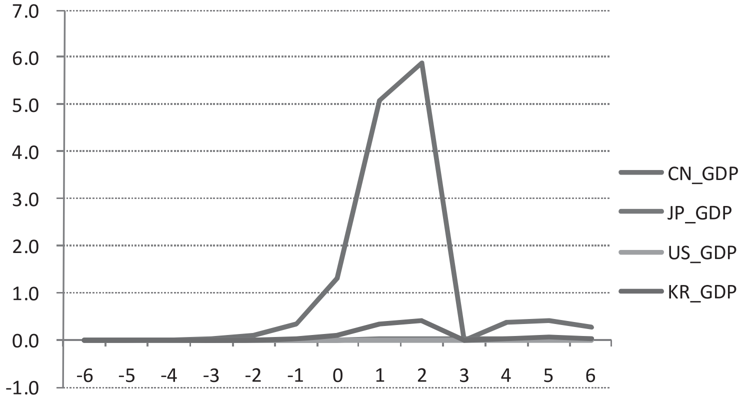
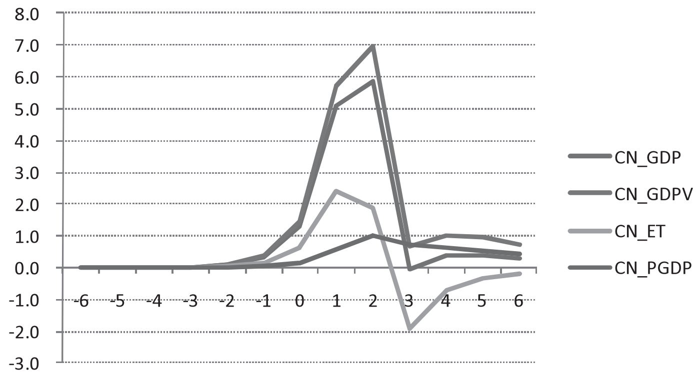


Table 12 The Domestic Effects for China

	CN_GDP	CN_GDPV	CN_ET	CN_PGDP
-2	0.09	0.10	0.04	0.01
-1	0.34	0.38	0.16	0.04
0	1.33	1.47	0.64	0.14
1	5.24	5.90	2.47	0.63
2	5.88	6.97	1.82	1.03
3	-0.02	0.68	-1.92	0.71
4	0.38	1.04	-0.74	0.65
5	0.42	1.00	-0.32	0.57
6	0.30	0.77	-0.20	0.47

Figure 5 The Domestic Effects for China



The US stimulus package: government investment

The results for the US stimulus package, which is limited only to the area of construction and related spending, appear somewhat similar to those from the test for fiscal expansion above. The effect on GDP is estimated to be around 0.94%, and expected to increase employment by up to 0.42%.

As for the effects on the world economy, a 0.94% expansion of the US economy brings on a rather small increase in the world economy, remaining negligible for the Japanese economy especially, despite the US expansion.

Table 13 The Effects of the US Stimulus Package

	CN_GDP	JP_GDP	US_GDP	KR_GDP
-2	0.00	0.00	0.01	0.00
-1	0.01	0.00	0.06	0.01
0	0.02	0.00	0.25	0.02
1	0.05	0.00	0.94	0.07
2	0.04	0.00	0.94	0.07
3	0.02	0.00	0.40	0.02
4	0.00	0.00	-0.14	-0.01
5	0.00	0.00	-0.12	-0.01
6	0.00	0.00	-0.09	-0.01

Figure 6 The US Stimulus Package

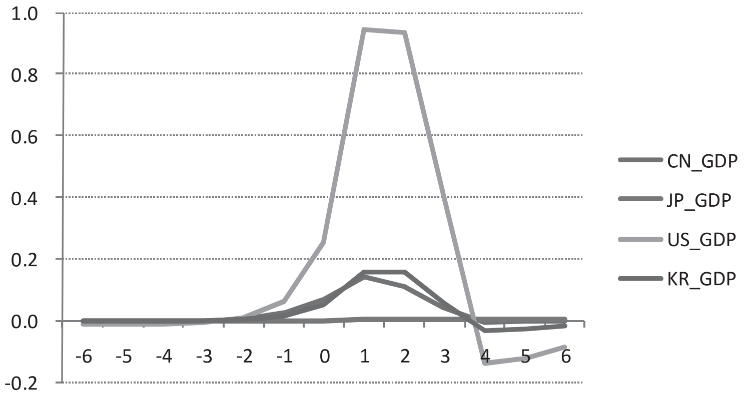
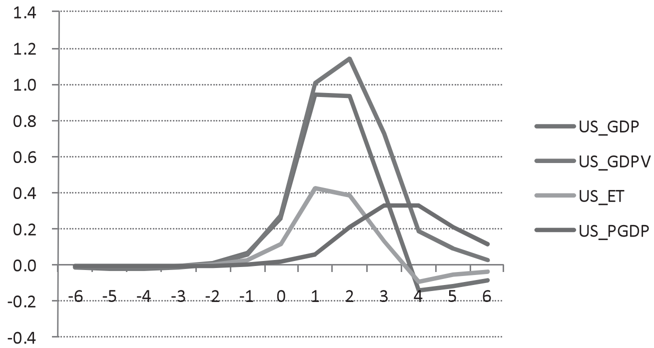


Table 14 The Domestic Effects for the United States

	US_GDP	US_GDPV	US_ET	US_PGDP
-2	0.01	0.00	0.00	-0.01
-1	0.06	0.06	0.03	0.00
0	0.25	0.27	0.11	0.01
1	0.94	1.00	0.42	0.06
2	0.94	1.14	0.38	0.20
3	0.40	0.73	0.13	0.32
4	-0.14	0.19	-0.09	0.32
5	-0.12	0.09	-0.05	0.21
6	-0.09	0.03	-0.03	0.11

Figure 7 The Domestic Effects for the United States



The US stimulus package: tax cuts and subsidies

This simulation is for the evaluation of the effects relating to the tax cuts and subsidies which are included in the stimulus package and are assumed to increase household disposable income. This stimulus expands US GDP by up to 0.68%, and therefore the combined effect on GDP together with government investment amounts to around 1.61%.

A predominant part of the increase comes from private consumption, which shows a 0.9% increase at its peak. In addition, this type of fiscal spending has more labor-augmenting characteristics than government investment, and therefore appears to be more efficient in securing employment.

Table 15 The Effects of Tax Cuts and Subsidies

	CN_GDP	JP_GDP	US_GDP	KR_GDP
-2	0.00	0.00	0.00	0.00
-1	0.00	0.00	-0.12	-0.01
0	0.01	0.00	0.05	0.01
1	0.04	0.00	0.65	0.05
2	0.03	0.00	0.68	0.05
3	0.02	0.00	0.41	0.03
4	0.01	0.00	0.22	0.01
5	0.01	0.00	0.13	0.01
6	0.00	0.00	0.07	0.00

Figure 8 The Effect of Tax Cuts and Subsidies

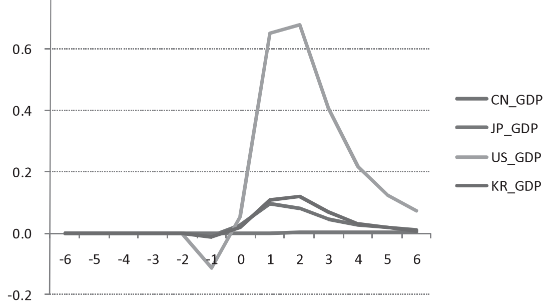


Table 16 Domestic Effects

	US_GDP	US_GDPV	US_ET	US_PGDP	US_C
-2	0.00	0.00	0.00	0.00	0.02
-1	-0.12	-0.22	-0.04	-0.10	0.04
0	0.05	-0.04	0.03	-0.09	0.07
1	0.65	0.59	0.30	-0.05	0.69
2	0.68	0.75	0.28	0.07	0.90
3	0.41	0.59	0.15	0.19	0.65
4	0.22	0.44	0.08	0.22	0.35
5	0.13	0.32	0.04	0.20	0.19
6	0.07	0.23	0.03	0.16	0.10

Figure 9 Domestic Effects

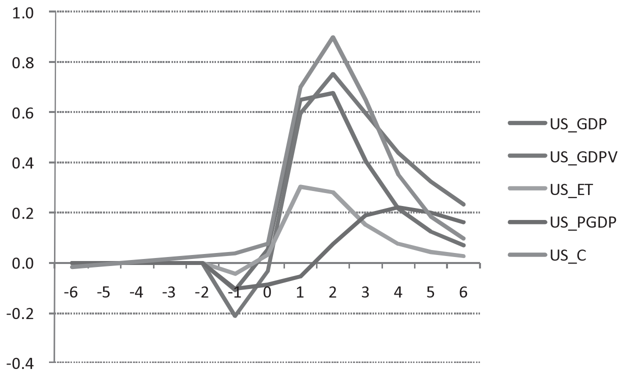


Table 17 Total Effect of US Stimulus Package

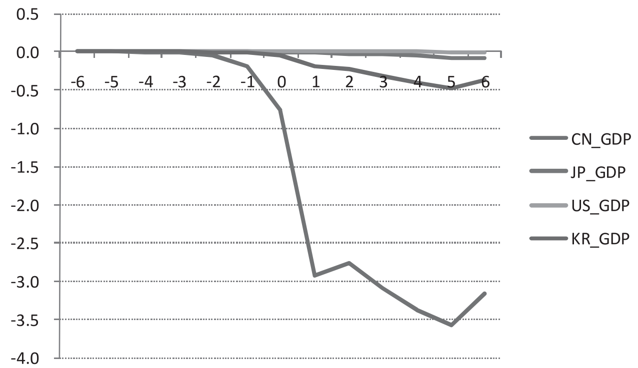
	CN_GDP	JP_GDP	US_GDP	KR_GDP
-2	0.00	0.00	0.00	0.00
-1	0.02	0.00	-0.05	0.00
0	0.09	0.00	0.31	0.07
1	0.24	0.00	1.60	0.26
2	0.19	0.01	1.61	0.28
3	0.09	0.01	0.80	0.13
4	0.02	0.01	0.08	0.00
5	0.02	0.01	0.00	-0.01
6	0.01	0.01	-0.02	-0.01

5) Changes in Exchange Rates

Appreciation of the yuan (RMB)

The appreciation of the yuan leads to a drastic slowdown in China's economy by around 3–4%. In addition to this, it is very distinctive that China's slowdown makes other nations' economies shrink at the same time by up to 1% and its slowdown in exports leads to a simultaneous reduction in ROK exports.

Figure 10 Effects of the Appreciation of the Yuan

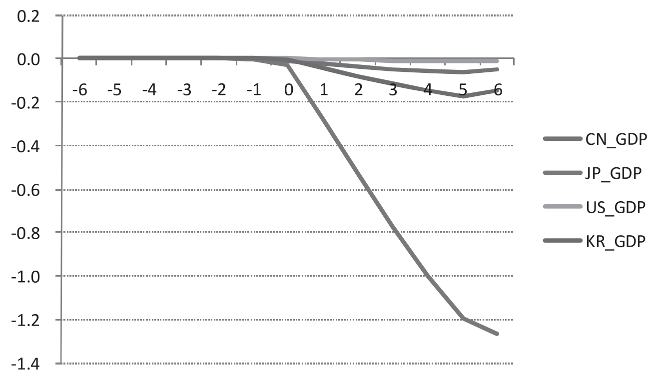


In Ban (2000), the reduction of GDP is estimated at around 3% in 2001. Our estimate is rather drastic, and this reflects the fact that the Chinese economy has enhanced its export-dependent characteristics compared to previously; the export to GDP ratio was 23% in 2001, and exceeded 34% in 2005.

Appreciation of the yen

The appreciation of the yen also largely affects the Japanese economy: it slows down the GDP of Japan by around -1.3%. There may be a large drop in the GDP of the neighboring country, the ROK, of -0.2%.

Figure 11 Effects of the Appreciation of the Yen



The reduction in the GDP of Japan will greatly induce simultaneous Chinese and ROK reductions in exports, because of the growing mutual dependency compared with one or two decades before.

For reference, we quote the results of the simulation carried out by Ban (2000), and the reaction of China is quite different compared to the case above. According to their work, the reduction in Japanese exports was simultaneously filled by the exports of third countries, which boosted the other nations' economies. This means that substitution among exporting countries has diminished with the rising trend of cooperative and complementary relations.

The effects of stimulus packages estimated by the IMF

IMF (2009b) estimates of the multipliers of fiscal expansion use the GIMF model (Kumhof and Laxton, 2009). Japanese multipliers are estimated as much smaller than in our case. The effects on other countries regarding US and Japanese expansion are not estimated to be high, which is similar to our results.

According to our measurement, Japan and the United States seem rather "isolated" despite the era of integration, because both countries are too large to be able to detect separately the effects of the fiscal stimulus.

Tables 18 and 19 IMF Estimates

Table 3. Growth Effects of Fiscal Stimulus in 2009 and 2010

(Deviation from baseline in percentage points)

	Stimulus in:					
	All	U.S.	Euro Area	Japan	Em. Asia	RoW
Effects on Growth in 2009						
World	1.4	0.5	0.2	0.1	0.4	0.2
United States	1.5	1.3	0.0	0.0	0.1	0.1
Euro Area	0.9	0.2	0.5	0.0	0.1	0.1
Japan	1.1	0.2	0.0	0.7	0.1	0.0
Emerging Asia	2.1	0.6	0.1	0.1	1.3	0.1
Remaining Countries	1.0	0.3	0.1	0.0	0.2	0.4
Effects on Growth in 2010						
World	0.7	0.9	-0.0	0.0	-0.2	-0.0
United States	1.5	1.4	0.0	0.0	0.0	0.0
Euro Area	0.3	0.5	-0.2	0.0	0.0	0.0
Japan	0.4	0.5	0.0	-0.2	-0.0	0.0
Emerging Asia	0.2	1.1	0.0	0.0	-0.9	0.0
Remaining Countries	0.6	0.7	0.0	0.0	-0.0	-0.1

Table 4. Level Effects of Fiscal Stimulus in 2009 and 2010

(Percent deviation from baseline in percent)

	Stimulus in:					
	All	U.S.	Euro Area	Japan	Em. Asia	RoW
Effects on GDP in 2009						
World	1.4	0.5	0.2	0.1	0.4	0.2
United States	1.5	1.3	0.0	0.0	0.1	0.1
Euro Area	0.9	0.2	0.5	0.0	0.1	0.1
Japan	1.1	0.2	0.0	0.7	0.1	0.0
Emerging Asia	2.1	0.6	0.1	0.1	1.3	0.1
Remaining Countries	1.0	0.3	0.1	0.0	0.2	0.4
Effects on GDP in 2010						
World	2.0	1.4	0.1	0.1	0.2	0.2
United States	3.1	2.7	0.1	0.1	0.1	0.1
Euro Area	1.2	0.6	0.3	0.1	0.1	0.1
Japan	1.5	0.7	0.1	0.5	0.1	0.1
Emerging Asia	2.3	1.6	0.1	0.1	0.4	0.1
Remaining Countries	1.7	1.0	0.1	0.1	0.2	0.3

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Appendix A

List of the Principal Equations of the Model

(1) China Model

(Identity)

CN_GDP = CN_C + CN_IF + CN_GC + CN_X - CN_M
CN_GDPV = CN_CV + CN_IFV + CN_GCV + CN_XV - CN_MV
CN_CV = CN_C * CN_PC / 100
CN_IFV = CN_IF * CN_PIF / 100
CN_GCV = CN_GC * CN_PGC / 100
CN_XV = CN_X * CN_PX / 100
CN_BAL = CN_XV - CN_MV
CN_PEDYV = CN_PEWFP + CN_PEOY + CN_GEOTH - CN_TY
CN_PEWFP = CN_ER * CN_ET / 1000000
CN_IF = CN_IBUDV / CN_PIF * 100 + CN_IFOR + CN_ILON + CN_IFF + CN_GISIM

(Consumption)

CN_C = 55.11 + 0.108*CN_PEDYV/CN_PC*100
(2.53) (5.52)
+ 0.0052*(1/(1 + CN_RLG(+ 1)/100))*CN_PENW(+ 1)/CN_PC(+ 1)*100 + 0.871*CN_C(- 1)
(2.12) (4.96)
D.W.=1.20 R^2(adj)=0.997

CN_PENW = 1364.81 + CN_PENW(- 1) + 0.329*(CN_PEDYV - CN_CV) + [AR(1) = 0.916]
(1.00) (2.76) (12.7)
D.W.=1.35 R^2(adj)=0.999

(Investment)

CN_IFF/CN_K(- 1) = -0.0816 + 0.223*(1/(1 + CN_RLG(+ 1)/100)*CN_GDP(+ 1)/CN_K(- 1))
(-0.95) (3.29)
+ 43.06*CN_COGTP/CN_PIF/CN_K(- 1) + 8.895e-13*EXP(TREND)
(4.05) (2.91)
D.W.=0.83 R^2(adj)=0.999

CN_COGTP = 221.87 + 0.839*(CN_GDPV - CN_PEDYV) + 0.580*CN_TXIV + [AR(1) = 0.776]
(0.64) (5.04) (0.82) (3.90)
D.W.=1.23 R^2(adj)=0.991

(Prices and Wages)

LOG(CN_PC) = 0.113 + 0.718*LOG(CN_PC(- 1)) + 0.128*LOG(CN_ER)
(0.72) (7.54) (2.39)
+ 0.388*LOG(CN_MON2/CN_MON2(- 1))
(3.29)
D.W.=0.69 R^2(adj)=0.976

LOG(CN_PIF) = 0.107 + 0.374*LOG(CN_PM) + 0.308*LOG(CN_ER)
(0.56) (4.29) (6.93)
+ 0.255*LOG(CN_MON2/CN_MON2(- 1))
(0.95)
D.W.=0.76 R^2(adj)=0.967

LOG(CN_ER) = 8.669 + 0.849*LOG(CN_GDP/CN_ET) + 0.838*LOG(CN_PC(- 1))
(17.0) (14.0) (14.5)

D.W.=0.89 R^2(adj)=0.995

(Interest rates)

CN_RLG = 10.67 + 0.375*CN_RLG(- 1) + (1 - 0.375)*LOG(CN_PGDP(+ 1)/CN_PGDP)
(4.88) (3.24)
- 1.533*LOG((CN_MON2 - CN_GGDBT)/CN_PGDP) - 19.28*LOG(CN_YHAT(- 1)/CN_GDP(- 1))
(-4.65) (-0.50)
D.W.=1.52 R^2(adj)=0.899

CN_RSH is exogenous for the China model

(Labor)

LOG(CN_ET) = 6.309 + 0.5452*LOG(CN_GDP) - 0.493*LOG(CN_GDP(- 1)/CN_ET(- 1))
(5.76) (7.44) (-5.09)
D.W.=1.09 R^2(adj)=0.921

CN_U = CN_LS - CN_ET
CN_UP = 1*(CN_U/CN_LS*100)

(Trade and Import Prices)

TX_CHWD99 = TM_CHJP99 + TM_CHKR99 + TM_CHUS99 + TX_CHRW99
TX_CHWD99R = TX_CHWD99/CN_PX$*100
TM_WDCH99R = TM_JPCH99/JP_PX$*100 + TM_KRCH99/KR_PX$*100
+ TM_USCH99/US_PX$ * 100 + TX_RWCH99/RW_PX$*100
TM_WDCH99 = TM_JPCH99 + TM_KRCH99 + TM_USCH99 + TX_RWCH99

TM_JPCH99/TM_WDCH$ = -1.578 + 0.296*LOG(CN_GDP) - 0.01*LOG(JP_PX$/WD_WPI)
(-3.39) (4.38) (*)
-0.164*LOG(KR_PX$/WD_WPI) - 0.0277*LOG(US_PX$/WD_WPI) - 0.0505*TREND
(-3.55) (-0.71) (-5.87)
D.W.=1.53 R^2(adj)=0.717

TM_KRCH99/TM_WDCH$ = -0.805 + 0.138*LOG(CN_GDP) - 0.0915*LOG(JP_PX$/WD_WPI)
(-1.58) (1.83) (-1.23)
-0.0364*LOG(KR_PX$/WD_WPI) - 0.0206*LOG(US_PX$/WD_WPI) - 0.0198*TREND
(-0.93) (-0.43) (-2.01)
D.W.=0.85 R^2(adj)=0.917

TM_USCH99/TM_WDCH$ = 0.232 + 0.00245*LOG(CN_GDP) - 0.0469*LOG(JP_PX$/WD_WPI)
(0.58) (0.96) (-0.79)
-0.0131*LOG(KR_PX$/WD_WPI) - 0.000233*LOG(US_PX$/WD_WPI) - 0.00854*TREND
(-0.42) (0.1) (-1.08)
D.W.=1.46 R^2(adj)=0.744

CN_PM$ = -0.000895 + 1.00*TM_WDCH99/TM_WDCH99R*100
CN_PM = 7.707 + 0.120*CN_PM$*CN_RXD

(2) Japan Model

(Identity)

JP_GDP = JP_C + JP_IF + JP_GC + JP_X - JP_M
JP_GDPV = JP_CV + JP_IFV + JP_GCV + JP_XV - JP_MV
JP_CV = JP_C * JP_PC / 100
JP_IFV = JP_IF * JP_PIF / 100
JP_GCV = JP_GC * JP_PGC / 100

JP_BAL = JP_XV - JP_MV

JP_PEDYV = JP_PEWFP + JP_PEOY + JP_GEOTH - JP_TY - JP_TYSIM

JP_IF = JP_GIV / JP_PIF * 100 + JP_IFF + JP_GISIM

(Consumption)

JP_C = 23545.51 + 0.295*JP_PEDYV/JP_PC*100
(1.05) (2.60)
+ 0.010*(1/(1 + JP_RLG(1)/100))*JP_PENW(1)/JP_PC(1)*100 + 0.564*JP_C(- 1)
(2.07) (5.81)
D.W.=1.40 R^2(adj)=0.983

JP_PENW = JP_PENW(- 1) + 1.991*(JP_PEDYV - JP_CV)

(Investment)

JP_IFF/JP_K(- 1) = -0.024 + 0.2002*(1/(1 + JP_RLG(+ 1)/100)*JP_GDP(+ 1)/JP_K)
(-0.31) (2.18)
+ 21.454*JP_MON(- 1)/JP_PIF(- 1)/JP_K(- 1) + [AR(1) = 1.056]
(2.48) (25.7)
D.W.=1.36 R^2(adj)=0.768

(Prices and Wages)

LOG(JP_PC) = 0.633 + 0.294*LOG(JP_ER(- 1)) + 0.435*LOG(JP_PC(- 1)) - 0.0335*LOG(TREND)
(3.59) (2.49) (2.52) (-7.44)
D.W.=1.38 R^2(adj)=0.956

LOG(JP_PIF) = 0.318 + 0.00174*LOG(JP_PM(- 1)) + 0.699*LOG(JP_ER(- 1)) - 0.208*LOG(TREND)
(0.64) (0.96) (11.4) (-23.7)
D.W.=0.91 R^2(adj)=0.954

LOG(JP_ER) = -0.511 + 1.636*LOG(JP_PC(- 1)) - 0.669*LOG(JP_YHAT/JP_GDP)
(-1.15) (16.8) (-5.84)
D.W.=1.86 R^2(adj)=0.965

(Interest rates)

JP_RSH = 16.03 + 0.684*JP_RSH(- 1) + (1 - 0.684)*LOG(JP_PGDP(+ 1)/JP_PGDP)
(1.40) (6.43)
- 1.50*LOG((JP_MON - JP_GGDBT/100)/JP_PGDP) - 30.27*LOG(JP_YHAT/JP_GDP)
(-1.59) (-3.31)
D.W.=1.70 R^2(adj)=0.924

JP_RLG = 1.257 + 0.203*JP_RLG(+ 1) + 0.595*(JP_RSH)
(4.04) (1.09) (4.34)
D.W.=1.87 R^2(adj)=0.940

(Labor)

LOG(JP_ET) = 1.725 + 0.231*LOG(JP_GDP) - 0.272*LOG(JP_GDP(- 1)/JP_ET(- 1))
(1.87) (2.17) (-2.64)
+ 0.620*LOG(JP_ET(- 1))
(8.20)
D.W.=1.31 R^2(adj)=0.887

LOG(JP_U) = 6.897 - 25.42*LOG(JP_ET/JP_LS) + [AR(1) = 0.927]
(27.6) (-11.9) (9.25)
D.W.=0.69 R2(adj)=0.994

JP_UP = JP_U / JP_LS * 100

(Trade and Import Prices)
TX_JPWD99 = TM_JPCH99 + TM_JPKR99 + TM_JPUS99 + TX_JPRW99
TX_JPWD99R = TX_JPWD99/JP_PX$*100
TM_WDJP99R = TM_CHJP99/CN_PX$*100 + TM_KRJP99/KR_PX$*100
+ TM_USJP99/US_PX$*100 + TX_RWJP99/RW_PX$*100
TM_WDJP99 = TM_CHJP99 + TM_KRJP99 + TM_USJP99 + TX_RWJP99
TM_CHJP99/TM_WDJP$ = -2.180 + 0.174*LOG(JP_GDP) - 0.0956*LOG(CN_PX$/WD_WPI)
(-1.47) (1.55) (-1.95)
- 0.0952*LOG(KR_PX$/WD_WPI) + 0.137*LOG(US_PX$/WD_WPI)
(-2.79) (3.61)
D.W=0.56 R^2(adj)=0.948
TM_KRJP99/TM_WDJP$ = -1.298 + 0.105*LOG(JP_GDP) - 0.0107*LOG(CN_PX$/WD_WPI)
(-1.71) (1.80) (-0.45)
- 0.05*LOG(KR_PX$/WD_WPI) + 0.0705*LOG(US_PX$/WD_WPI) - 0.00294*TREND
(*) (3.93) (-2.44)
D.W.=1.40 R^2(adj)=0.08
TM_USJP99/TM_WDJP$ = -1.022 + 0.119*LOG(JP_GDP) + 0.0945*LOG(CN_PX$/WD_WPI)
(-0.92) (1.38) (3.16)
- 0.122*LOG(KR_PX$/WD_WPI) - 0.0620*LOG(US_PX$/WD_WPI) - 0.0196*TREND
(-5.14) (-2.00) (-10.1)
D.W.=1.72 R^2(adj)=0.965
JP_PM$ = 0.905*TM_WDJP99/TM_WDJP99R*100
JP_PM = 0.01*JP_PM$*JP_RXD

(3) ROK Model
(Identity)
KR_GDP = KR_C + KR_IF + KR_GC + KR_X - KR_M
KR_GDPV = KR_CV + KR_IFV + KR_GCV + KR_XV - KR_MV
KR_CV = KR_C * KR_PC / 100
KR_IFV = KR_IF * KR_PIF / 100
KR_GCV = KR_GC * KR_PGC / 100
KR_XV = KR_X * KR_PX / 100
KR_BAL = KR_XV - KR_MV
KR_PEDYV = KR_PEWFP + KR_PEOY + KR_GEOTH - KR_TY
KR_IF = KR_GIV / KR_PIF * 100 + KR_IFF + KR_GISIM
(Consumption)
KR_C = -39773.85 + 0.807*KR_PEDYV/KR_PC*100
(2.21) (10.5)
+ 0.0573*(1/(1 + KR_RLG(1)/100))*KR_PENW(1)/KR_PC(1)*100 - 48812.36*D98
(6.79) (-5.30)
D.W.=1.20 R^2(adj)=0.972
KR_PENW = KR_PENW(- 1) + 2.750*(KR_PEDYV - KR_CV)
(Investment)
KR_IFF/KR_K(- 1) = -0.0761 + 0.127*(1/(1 + KR_RLG(+ 1)/100)*KR_GDP(+ 1)/KR_K)
(-1.14) (0.94)

+ 50.07*KR_COGTP(- 1)/KR_PIF(- 1)/KR_K(- 1)
(3.46)

D.W.=1.02 R^2(adj)=0.785

KR_COGTP = 245346.37 + 0.236*(KR_GDPV - KR_PEDYV) - 0.860*KR_TC + [AR(1) = 0.908]
(1.97) (1.33) (-0.85) (14.2)

D.W.=2.00 R^2(adj)=0.973

(Price and Wages)

LOG(KR_PC) = 0.174 + 0.635*LOG(KR_PC(- 1)) + 0.203*LOG(KR_ER)
(5.39) (14.2) (7.46)

D.W.=1.29 R^2(adj)=0.998

LOG(KR_PIF) = 0.464 + 0.247*LOG(KR_PM) + 0.401*LOG(KR_ER)
(3.96) (6.22) (33.4)

D.W.=0.65 R^2(adj)=0.994

LOG(KR_ER) = -0.0527 + 1.381*LOG(KR_GDP/KR_ET) + 0.655*LOG(KR_PC(- 1))

(Interest Rates)

KR_RSH = 17.04 + 0.590*KR_RSH(- 1) + (1 - 0.590)*LOG(KR_PGDP(+ 1)/KR_PGDP)
(1.72) (9.70)
- 3.513*LOG((KR_MON - KR_GGDBT/100)/KR_PGDP) - 7.441*LOG(KR_YHAT/KR_GDP)
(-7.11) (-0.28)

D.W.=2.33 R^2(adj)=0.729

KR_RLG = 1.366 + 0.385*KR_RLG(+ 1) + 0.583*(KR_RSH)
(2.02) (3.49) (5.02)

D.W.=1.57 R^2(adj)=0.931

(Labor)

LOG(KR_ET) = 4.636 + 0.457*LOG(KR_GDP) - 0.224*LOG(KR_GDP(- 1)/KR_ET(- 1))
(7.88) (6.92) (-2.51)

D.W.=1.19 R^2(adj)=0.983

KR_U = KR_LS - KR_ET

KR_UP = KR_U / KR_LS * 100

(Trade and Import Prices)

TX_KRWD99 = TM_KRCH99 + TM_KRJP99 + TM_KRUS99 + TX_KRRW99

TX_KRWD99R = -21592.23 + 1.00*TX_KRWD99/KR_PX$*100

TM_WDKR99 = TM_CHKR99 + TM_JPKR99 + TM_USKR99 + TX_RWKR99

TM_WDKR99R = TM_CHKR99/CN_PX$*100 + TM_JPKR99/JP_PX$*100 + TM_USKR99/US_PX$*100
+ TX_RWKR99/RW_PX$*100

TM_JPKR99/TM_WDKR$ = -2.485 + 0.223*LOG(KR_GDP) - 0.01*LOG(JP_PX$/WD_WPI)
(-2.04) (2.28) (*)
- 0.128*LOG(CN_PX$/WD_WPI) + 0.162*LOG(US_PX$/WD_WPI) - 0.0150*TREND(- 1)
(-1.99) (3.33) (-2.94)

D.W.=1.22 R^2(adj)=0.819

TM_CHKR99/TM_WDKR$ = -1.021 + 0.0679*LOG(KR_GDP) + 0.0622*LOG(JP_PX$/WD_WPI)
(-1.34) (1.10) (1.19)
+ 0.00393*LOG(CN_PX$/WD_WPI) + 0.0353*LOG(US_PX$/WD_WPI) + 0.0116*TREND
(0.09) (1.01) (3.31)

D.W.=1.28 R^2(adj)=0.960

TM_USKR99/TM_WDKR$ = 0.467 + 0.00181*LOG(KR_GDP) - 0.123*LOG(JP_PX$/WD_WPI)
(0.48) (0.02) (-2.76)
+ 0.0171*LOG(CN_PX$/WD_WPI) - 0.01*LOG(US_PX$/WD_WPI) - 0.0172*TREND
(0.32) (*) (-4.31)
D.W.=1.19 R^2(adj)=0.920
KR_PM$ = 65.41 + 0.260*TM_WDKR99/TM_WDKR99R*100
KR_PM = KR_PM$ * KR_RXD / 1000

(4) U.S. Model
(Identity)
US_GDP = US_C + US_IF + US_GC + US_X - US_M
US_GDPV = US_CV + US_IFV + US_GCV + US_XV - US_MV
US_CV = US_C * US_PC / 100
US_IFV = US_IF * US_PIF / 100
US_GCV = US_GC * US_PGC / 100
US_BAL = US_XV - US_MV
US_PEDYV = US_PEWFP + US_PEOY + US_GEOTH - US_TY + US_TYSIM + US_GESIM
US_IF = US_GIV / US_PIF * 100 + US_IFF + US_GISIM
TX_USWD99 = TM_USCH99 + TM_USJP99 + TM_USKR99 + TX_USRW99
TX_USWD99R = TX_USWD99 / US_PX$ * 100
US_M = US_MV / US_PM * 100
US_TAXES = US_TY + US_TX + US_TP + US_TSS + US_TC
US_GREV = US_TAXES + US_GREVO
US_GEXP = US_GCV + US_GIV + US_GEXPO
(Consumption)
US_C = -371.55 + 0.502*US_PEDYV/US_PC*100
(3.91) (4.65)
+ 0.000904*((1/(1 + US_RLG(1)/100))*US_PENW(1)/US_PC(1)*100 + (1/(1 + US_RLG/100))
(2.53)
*US_PENW/US_PC*100) + 0.515*US_C(- 1)
(5.15)
D.W.=1.12 R^2(adj)=0.999
US_PENW = US_PENW(- 1) + 8.512*(US_PEDYV - US_CV) + 3.912*US_PENAF
(Investment)
US_IFF/US_K(- 1) = -0.282 + 0.434*(1/(1 + US_RLG(+ 1)/100)*US_GDP(+ 1)/US_K)
(-3.08) (3.71)
+ 26.979*US_COGTP/US_PIF/US_K(- 1) + 0.0321*D2000
(1.27) (9.71)
D.W.=2.08 R^2(adj)=0.923
(Prices and Wages)
LOG(US_PC) = -3.252 + 0.642*LOG(US_ER) + 0.430*LOG(US_PM(- 1))
(-5.40) (29.1) (4.01)
D.W.=0.95 R^2(adj)=0.975
LOG(US_PIF) = 0.901 + 0.217*LOG(US_ER) + 0.376*LOG(US_PM(- 1))
(2.25) (10.9) (5.57)

D.W.=0.95 R^2(adj)=0.975

LOG(US_ER) = 4.728 + 0.571*LOG(US_GDP(- 1)/US_ET(- 1)) + 0.651*LOG(US_ER(- 1))
(2.80) (2.41) (5.57)

D.W.=1.36 R^2(adj)=0.985

(Interest Rates)

US_RSH = 13.47 + 0.592*US_RSH(- 1) + (1 - 0.592)*LOG(US_PGDP(+ 1)/US_PGDP)
(4.20) (6.01)
- 2.16*LOG((US_MON - US_GGDBT/100)/US_PGDP) - 74.563*LOG(US_YHAT/US_GDP)
(-1.00) (-8.46)

D.W.=1.83 R^2(adj)=0.873

US_RLG = 0.0388 + (1 - 0.398)*US_RLG(+ 1) + 0.398*US_RLG(- 1) + 0.0607*(US_RSH)
(0.05) (4.45) (0.75)
- 0.0104*TREND
(-0.40)

D.W.=2.89 R^2(adj)=0.867

(Labor)

LOG(US_ET) = 7.253 + 0.466*LOG(US_GDP) - 0.101*LOG(US_GDP(- 1)/US_ET(- 1)) + 0.0161*D2000
(7.31) (6.51) (-0.80) (4.77)

D.W.=1.21 R^2(adj)=0.993

US_U = -0.505 + 1.00*(US_LS - US_ET)

US_UP = -0.0222 + 1.00*(US_U/US_LS*100)

(Trade and Import Prices)

TM_WDUS99 = TM_CHUS99 + TM_JPUS99 + TM_KRUS99 + TX_RWUS99

TM_WDUS99R = TM_CHUS99/CN_PX$*100 - TM_JPUS99/JP_PX$*100 +TM_KRUS99/KR_PX$*100
+ TX_RWUS99/RW_PX$*100

TM_JPUS99/TM_WDUS$ = 0.0663 + 0.0388*LOG(US_GDP) - 0.0453*LOG(JP_PX$/WD_WPI)
(0.03) (0.14) (-0.53)
+ 0.150*LOG(KR_PX$/WD_WPI) - 0.278*LOG(CN_PX$/WD_WPI) - 0.0148*TREND
(1.05) (-1.41) (-1.24)

D.W.=1.49 R^2(adj)=0.910

TM_KRUS99/TM_WDUS$ = -0.666 + 0.0800*LOG(US_GDP) + 0.0288*LOG(JP_PX$/WD_WPI)
(-2.12) (2.16) (3.76)
- 0.01*LOG(KR_PX$/WD_WPI) + 0.000722*LOG(CN_PX$/WD_WPI) - 0.00173*TREND
(*) (0.06) (-1.25)

D.W.=0.755 R^2(adj)=0.744

TM_CHUS99/TM_WDUS$ = -1.0222 + 0.120*LOG(US_GDP) - 0.101*LOG(JP_PX$/WD_WPI)
(-0.45) (0.45) (-1.28)
+ 0.281*LOG(KR_PX$/WD_WPI) - 0.35*LOG(CN_PX$/WD_WPI) + 0.00225*TREND
(4.59) (*) (0.24)

D.W.=1.54 R^2(adj)=0.826

US_PM$ = 0.01*TM_WDUS99/TM_WDUS99R*100

US_PM = 1.00*US_PM$

Note: (*) denotes calibrated parameters

Appendix B
List of Variables

Unless otherwise stated, the unit for all local currencies is one billion
The list below is quoted from Oxford Economic Forecasting, now Oxford Economics. With respect to the Japan Model, however, the variable names are the same as in all the other countries' models.

BAL	Balance of payment	Identity
BASET	Bank total assets (yen trillion)	IFS Banking
BBIS	Bank BIS ratio (BT1+BT2 as % BRWA)	BOJ/other estimate
BBIST1	Bank tier 1 ratio (BT1 as % BRWA)	BOJ/other estimate
BBOND	Bank bond finance (yen trillion)	IFS Banking
BBP	Benchmark bond prices	Datastream
BCAP	Capital/financial account in BOP (yen billion) NSA	Datastream
BCU	Current account of the balance of payments (yen billion) SA	Datastream
BCURRATE	Current account as % nominal GDP	OEF calculated
BFORA	Bank foreign assets (yen trillion)	IFS Banking
BFORL	Bank foreign liabilities (yen trillion)	IFS Banking
BGOV	Bank claims on central government (yen trillion)	IFS Banking
BINEX	Bank interest expenses (yen trillion)	BOJ/other estimate
BININ	Bank interest income (yen trillion)	BOJ/other estimate
BLIAB	Bank total liabilities (yen trillion)	IFS Banking
BNPERF	Bank non-performing loans within BPRIV (yen trillion)	OEF estimate
BPERF	Bank performing loans within BPRIV total (yen trillion)	BPRIV-BNPERF
BPRIV	Bank domestic claims on non-cent. govt. (yen trillion)	IFS Banking
BPROF	Bank total operating profits (yen trillion)	BOJ/other estimate
BRES	Bank total reserves (yen trillion)	IFS Banking
BRWA	Bank risk-weighted assets (yen trillion)	BOJ/other estimate
BSER	Invisibles/services balance in BCU (yen billion) SA	Datastream
BSURP	Bank cumulative surplus after write-offs (yen trillion)	BPRIV-BNPERF
BT1	Bank tier 1 capital (yen trillion)	BOJ/other estimate
BT2	Bank tier 2 capital (yen trillion)	BOJ/other estimate
BTOTH	Bank other capital (yen trillion)	BOJ/other estimate
BTUSD	Bank subordinated debt (yen trillion)	BOJ/other estimate
BTUSP	Bank unrealized stock profits, net (yen trillion)	BOJ/other estimate
BVI	Visible trade balance, BOP basis (yen billion) SA	Datastream
BWAGE	Bank wage bill (yen trillion)	BOJ/other estimate
BWCUM	Bank cumulative write-offs of bad loans (yen trillion)	OEF estimate
BWRITE	Bank write-offs of bad debt out of profits (yen trillion)	OEF estimate
C	Consumer expenditure, (yen billion, 1995 prices) SA	Datastream
CARB	Carbon emissions, million metric tons	OEF calculated
CARS	Car sales, registrations (thou., av. quarterly, SA)	Datastream
CBANK	Bank credit from monetary auth. (yen trillion)	IFS Banking
CD	Consumer exp. - durables, (yen billion, 1995 prices)	Datastream, SA
CND	Consumer exp. - non-durables, (1995 prices)	Identity C-CD
CODIV	Company sector dividend payments (yen billion)	Identity =PEDIV

COGTP	Company profits (yen billion)	OEF calculated
CONAF	Assets, net acquisition fin. assets - companies (yen billion)	Identity
CONIR	Company sector net interest receipts (yen billion)	OEF calculated
CONSTR	Construction activity (1995=100) SA	METI
CONW	Company sector net wealth (yen billion)	Identity
CPI	Prices, CPI - total (1995=100) NSA	Datastream
CPIFU	Prices, CPI - fuel (1995=100) NSA	Datastream
CPIX	Prices, CPI - non-fuel goods and services	OEF calculated
CU	Capacity utilization (%)	ESM key statistics
CUMOD	Capacity utilization - model consistent version	OEF calculated
CV	Consumer Expenditure (yen billion) SA	Datastream
DCOAL	Coal, total demand (mtoe)	OECD IEA Energy
DELTA	Depreciation rate for capital stock	OEF calculated
DGAS	Gas, total demand (mtoe)	OECD IEA Energy
DIV	Dividends index	Datastream
DIVT	Target dividend yield ratio	OEF estimate
DOIL	Oil, total demand (mtoe)	OECD IEA Energy
DOMD	Domestic demand SA	C+IF+GC+IS
DOTH	Banks' other liabilities (yen trillion)	IFS Banking
DPRIV	Bank demand/time/savings deposits (yen trillion)	IFS Banking
DSMP	Stockmarket prices based on DY ratio model	OEF calculated
EE	Employees in employment (thou.)	QLFS Item 40
EQMON	Money supply, equilibrium	OEF calculated
ER	Earnings, economy-wide average (yen thou.)	OEF calculated
ES	Employment, self employed (thou.)	OEF calculated
ESTAR	Employment at NAIRU (thou.)	OEF calculated
ET	Employment, total (thou.) SA	Datastream
FASSET$	Foreign assets (US$ billion)	IFS
FDI$	Incoming foreign direct investment, net total (US$m)	Datastream
FLIAB$	Foreign liabilities (US$ billion)	IFS
GB	Government (general) balance (yen billion)	ARNA
GBCEN	Government balance, alternative (yen billion) NSA	Datastream
GBPUB	Government balance, public sector (yen billion) NSA	Datastream
GC	Public consumption, (yen billion, 1995 prices) SA	Datastream
GCGPE	Transfers, personal sector from central govt. (yen billion)	ARNA Part 3 II
GCV	Public consumption (yen billion) SA	Datastream
GDIP	Government interest payments, gross (yen billion)	ARNA Part 3 SA
GDIR	Government debt interest receipts (yen billion)	Identity GDIP-GNIP
GDP	GDP (yen billion, 1995 prices) SA	Datastream
GDP$	GDP, US$ million, 1995 prices SA	World Bank, WDI
GDP$V	GDP nominal in US$ millions (SA)	Identity
GDPV	GDP (yen billion) SA	Datastream
GEOTH	Government expenditure, others	
GEXP	Government expenditure, total (yen billion)	ARNA Part3, II
GGDBT	Government (central) debt -stock gross (fin. liab.)	Datastream
GI	Investment by government, (yen billion, 1995 prices) SA	Datastream
GIV	Public investment spending (yen billion) SA	ARNA Part3, II
GNDBT	Government NET debt - stock, net (yen billion)	OEF calculated

GNIP	Government interest payments, net (yen billion)	ARNA Part3 SA
GREV	Government revenue, total (yen billion)	ARNA Part3, II
GREVO	Government revenue, others	
IBUDV	Investment from government budget	
IF	Investment, total (yen billion, 1995 prices) SA	Datastream
IFF	Investment, private sector, real	
IFOR	Investment, net FDI	
IFV	Investment, total (yen billion) SA	Datastream
ILON	Investment funded by loans	
INRS	Investment, private nonresidential - structures	(12.4/26.1)*IPNR
IP	Industrial production index (1995=100) SA	Datastream
IPDE	Investment, private nonresidential - equipment	IPNR-INRS
IPEO	Investment, private investment - other equipment	0.7*IPDE
IPETR	Investment, private, equipment, transportation	0.3*IPDE
IPNR	Investment, private-sector business (yen billion,1995 prices) SA	Datastream
IPRD	Investment in private dwellings, (yen billion,1995 prices) SA	Datastream
IS	Stock-building, (yen billion, 1995 prices) SA	GDP-C-IF-GC
ISV	Stock-building (yen billion) SA	GDPV-CV-IFV
K	Capital stock, constant prices	OEF calculated
LS	Labor supply (thou.)	Identity ET+U
M	Imports of goods and services, total, constant prices SA	Datastream
M$V	Imports of goods and services, total in US$	
MCOAL	Imports of coal, mtoe	
MFU	Imports of fuels, constant prices (1995 based)	OECD ITCI
MG	Imports of goods, (yen billion, 1995 prices)	100*MGV/PMG
MGAS	Imports of natural gas, mtoe	
MGNF	Imports of goods, non-fuel, constant prices	MG-MFU
MGV	Imports of goods, (yen billion) SA	Datastream
MMWP	Macro-model weighted profits	OEF calculated
MOIL	Imports of crude oil, mtoe	
MON or MON2	M2 Money demand - (yen billion)	Datastream
MPK	Marginal physical productivity of capital (%)	OEF calculated
MS	Imports of services, (yen billion, 1995 prices) SA	M-MG
MSV	Imports of services, current prices SA	MV-MGV
MV	Imports of goods and services, total (yen billion) SA	Datastream
NAIRU	Non-Accelerating Inflation Rate of Unemployment (%)	OEF calculated
NAIRUR	Parameter used in wage equation = NAIRU/UP	OEF calculated
NETR	Net transfers abroad on BCU, BOP basis (yen billion) SA	Datastream
NFDI$	Inflow of foreign investment excluding FDI	
NIPDV	Net IPD, BOP basis (yen billion) SA	Datastream
NLCOST	Costs of production, non-labor (index 1995=100)	OEF calculated
PART	Labor-force participation rate (%)	OEF calculated
PC	Consumer expenditure deflator (1995=100) SA	100*CV/C
PCOAL$	Coal, price average incl. carbon tax, US$ per toe	OECD IEA Energy
PCOLBT	Coal, price average in US$ per toe	OECD IEA Energy
PDFU	Fuel price, average 1995=100, local currency	Identity
PEDIP	Income, pers. sect. debt interest payments (yen billion)	ARNA Part 3 SA
PEDIR	Income, pers. sect. debt interest receipts (yen billion)	ARNA Part 3 SA

PEDIV	Income, personal sect. dividend receipts (yen billion)	ARNA Part 3 SA
PEDY	Income, real personal disposable, constant price	OEF calculated
PEDYV	Income, personal disposable, current prices	ARNA Part 3, II
PEMPY	Income, compensation from employment (yen billion)	Datastream
PENAF	Assets, acquisitions of financial assets - persons	ARNA Part 1 (2)
PENIR	Interest, pers. sect. net debt int. receipts (yen billion)	Identity
PENW	Wealth, personal sector net wealth (yen billion)	OEF calculated
PEOCR	Pension fund contribution by employers (yen billion)	ARNA Part 3 SA
PEOY	Income, "other" personal income (yen billion)	OEF calculated
PERF	Bank performing loans as proportion of BPRIV	(BPERF/BPRIV)
PERT	Target PE ratio	OEF estimate
PESR	Savings, personal sector savings rate (%)	OEF calculated
PESV	Savings, personal sector (yen billion)	OEF calculated
PEWFP	Wages and salaries (yen billion)	ARNA Part 3 SA
PGAS$	Gas, price average incl. carbon tax, US$ per toe	OECD IEA Energy
PGASBT	Gas, price average in US$ per toe	OECD IEA Energy
PGC	Public consumption deflator (1995=100) SA	100*GCV/GC
PGDP	GDP deflator (1995=100) SA	100*GDPV/GDP
PGDPX	Expected price level for exchange rate eq	OEF/user defined
PIF	Investment deflator (1995=100) SA	100*IFV/IF
PM	Import deflator - total (1995=100) SA	100*MV/M
PM$	Import deflator in $	
PMFU	Import price of fuels (1995=100)	OECD ITCI
PMG	Import deflator, goods NSA (1995=100)	Datastream
PMGNF	Imports deflator - goods, non fuel	OEF calculated
PMS	Import price of services (1995=100) SA	100*(MSV/MS)
POIL$	Oil, price average incl. carbon tax, US$ per toe	OECD IEA Energy
POILBT	Oil, price average in US$ per toe	OECD IEA Energy
POP	Population, total (thou.)	OECD/World Bank
POPW	Population of working age (thou.)	World Bank
PPI	Prices, producer (1995=100) NSA	Datastream
PROD	Productivity, trend	OEF calculated
PSH	Stock exchange index, Tokyo (4 January 1968=100)	Datastream
PSMP	Stockmarket prices based on PE ratio model	OEF calculated
PSTAR	Price level target for interest rate rule	OEF/user fixed
PX	Export deflator - total (1995=100) SA	100*XV/X
PX$	Export deflator in US$	
PXFU	Export price of fuels (1995=100)	OECD ITCI
PXG	Export deflator, goods NSA (1995=100)	Datastream
PXGNF	Export deflator - goods, non fuel	OEF calculated
PXS	Export price of services (1995=100) SA	100*XSV/XS
QCOAL	Coal, total production (mtoe)	OECD IEA Energy
QGAS	Gas, total production (mtoe)	OECD IEA Energy
QOIL	Oil, total production (mtoe)	OECD IEA Energy
QR	Relative return on investment - companies	OEF calculated
RDEP	Bank deposit rate (%)	Datastream
RES$	Reserves, Central Bank forex (US$ billion)	IFS
RES$M	Reserves, months of import cover	Identity

RISK	Exchange rate risk premium	OEF calculated
RLEND	Bank lending rate (%)	IFS via Datastream
RLG	Interest rate, benchmark long-bond (%)	Datastream
RRH	Interest rate, personal sector real (%)	OEF calculated
RRX	Real effective exchange rate (1990=100)	OEF
RS	Retail sales, constant prices index (1995=100)	(JPRETAILA*100)
RSH	Interest rate, 3-month rate on CDS (%)	Datastream
RX	Effective exchange rate (1990=100)	Datastream
RX1	Effective exchange rate (1990=100) OEF definition	OEF
RXD	Exchange rate, dollar rate	Datastream
RXDM	Exchange rate, Deutschmark rate	Datastream
RXDX	Expected exchange rate for exchange rate eq	OEF/user defined
RXEURO	Exchange rate, yen/euro	OEF estimate
RXPPP	Exchange rate, indicator for yen/US$ rate	OEF calculated
RXPPT	Exchange rate, indicator for yen/US$ rate	OEF calculated
SME	Stockmarket earnings	Datastream
SMP	Stockmarket index, Datastream total market	Datastream
ST	Stocks, total (yen billion, 1995 prices) SA	ST(-1)+IS
TAXEX	Tax, total receipts	
TAXRY		
TBALRATE	Trade balance as % nominal GDP	OEF calculated
TC	Tax, corporate taxes (yen billion)	ARNA Part 3, II
TCARB	Carbon tax, US$ per toe flat tax	OEF, zero base
TCOAL	Coal, tax rate, average (%)	OECD IEA Energy
TCOST	Costs, total (index 1995=100)	OEF calculated
TCR	Rate of corporate taxation (%)	OEF
TDMD$	Total energy demand	DCOAL*PCOAL+…+
TFE	Total final expenditure,(yen billion, 1995 prices) SA	C+GC+IF+IS+X
TGAS	Gas, tax rate, average (%)	OECD IEA Energy
TINT	Tax on bank deposits	
TM(i,j) nn	*i,j* compromises many combinations of trading partners; *nn* denotes classification item, 99 is all visible trade	COMTRADE
TM_ij	Trade from *i* to *j*, current US$ (importing data)	COMTRADE
TOIL	Oil, tax rate average (%)	OECD IEA Energy
TP	Tax, payroll (employer social sec. contrib. yen billion)	ARNA Part 3 SA
TPEN	Energy, total primary energy (mtoe)	OECD IEA Energy
TPR	Rate of payroll taxation (%)	OEF calculated
TRCOL	Time trend used in coal equations	OEF calculated
TREMP	Time trend in employment equation	1980 Q1 = 1
TREND	Trend productivity used in production function	OEF calculated
TRGAS	Time trend used in gas equations	OEF calculated
TRM	Time trend in imports equation	1973 Q1 = 1
TROIL	Time trend used for oil 1973	OEF calculated
TRX	Time trend in exports equation	1973 Q1 = 1
TSS	Social insurance contributions, employees (yen billion)	ARNA Part 3, II
TSSR	Rate of employee social security contributions (%)	OEF calculated
TX	Tax, expenditure tax (yen billion)	ARNA Part 3, II
TX_ij	Trade from *i* to *j*, current US$ (exporting data)	COMTRADE

TXAV	Tax, agricultural tax receipts	
TXFU	Tax, expenditure taxes on fuels (yen billion)	OEF calculated
TXIV	Tax, industrial and commercial tax receipts	
TXNFR	VAT rate of expend. taxation (%), excl. fuel taxes	Ministry of Finance
TXOTH	Tax, other receipts	
TXR	Rate of expenditure tax, average effective (%)	OEF (TX/CV)
TXTV	Tax, tariff receipts	
TY	Tax, personal income tax (yen billion)	ARNA Part 3, II
TYR	Rate of income taxation (%)	Min of Finance
U	Unemployment (thou.) SA	Datastream
UP	Unemployment (%) SA	Datastream
WC	Costs - unit wage whole economy (1995=100)	OEF calculated
WCMF	Costs - unit wage manufacturing (1995=100)	CSO (MRETS)
WCR	Costs, relative unit wage (1995=100)	CSO (MRETS)
WEDGE	"Wedge"	OEF calculated
WPI	World average wholesale price index	OEF calculated
WT	World trade index (1995=100)	OEF Calculated
WWC$	World wage costs index (1995=100)	OEF calculated
X	Exports of goods and services, total constant prices SA	Datastream
X$V	Exports of goods and services, total in US$	
XFU	Exports of fuels, constant prices (1995 base)	OECD ITCI
XG	Exports of goods, (yen billion, 1995 prices)	100*XGV/PXG
XGNF	Exports of goods, non fuel, constant prices	XG-XFU
XGV	Exports of goods, (yen billion) SA	Datastream
XS	Exports of services, (yen billion, 1995 prices) SA	X-XG
XSV	Exports of services, current prices SA	XV-XGV
XV	Exports of goods and services, total (yen billion) SA	Datastream
YHAT	Capacity output (constant prices, yen billion)	OEF calculated

Technological Progress, Technical Efficiency Change and Economic Growth in the Northeast of China: A Frontier Production-Analysis Approach

Nan Li*

Abstract

This paper discusses the change of productivity in the Northeast of China from 1978 to 2005. By constructing a stochastic frontier production function and making estimations using provincial-level panel data, three main findings are reported. Firstly, total factor productivity (TFP) plays a more important role over time, while the contribution of input factors (labor, capital, and other intermediate inputs) is still the major cause of economic growth. Secondly, regarding the two components of TFP, technological progress maintains a continual growth trend, whereas technical efficiency grows slowly. Thirdly, capital deepening is a major factor leading to technical inefficiency, and it will have an effect on the sustainable growth of China's Northeast.

Keywords: Economic growth, technological progress, technical efficient change; the Northeast of China

JEL Classification: O18; O33; O47; O53.

1. Introduction

Recently the Northeast of China has been playing a more important role in the economic development of Northeast Asia, especially with the deepening of the reform of state-owned enterprises and the implementing of the Strategy of the Revitalization of the Northeast Old Industrial Base. As a result, the total output of the Northeast of China has been increasing rapidly. In the past two decades, the average GDP growth rate has been about 9%, and the increases in GDP per capita and GDP per worker were nearly 8% and 6.7%, respectively. Meanwhile, the ratio of investment to GDP has increased from 0.162 in 1978 to 0.426 in 2005, and the average growth rate of the ratio of investment to GDP has been more than 4.1%[1]. The rapid growth has made the Northeast of China the engine of economic growth in Northeast Asia via foreign direct investment and international trade.

Are the trends of economic growth in this region of China sustainable, however? The "miracle" growth in East Asia reminds us that sustained economic growth not only depends on the increase of productive-factor input, but also on productivity growth (Krugman, 1994; Young, 1995). Hence, in this paper, the origin of economic growth in the Northeast of China is examined and the contribution of productivity to the process of growth is focused on.

In order to reveal the role of productivity in the process of growth, productivity

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[1] For more statistics and trends see Table A1 and Figure A1 (Appendix A).

growth is defined as the sum of technical efficiency change and technological progress, calculated via a stochastic frontier production function (Wu, 1995, 2000; Zhang, 2003, etc.). Here, technical efficiency change refers to the catching-up at the frontier of the product function and technological progress to changes at the frontier. This decomposition allows the identification of productivity growth due to either improvement in efficiency or technological progress. This approach helps us to understand the details of productivity change. Making estimations using provincial-level panel data, three main findings are reported. Firstly, total factor productivity (TFP) plays a more important role over time, while the contribution of input factors (labor, capital, and other intermediate inputs) is still the major cause of economic growth. Secondly, regarding the two components of TFP, technological progress maintains a continual growth trend, whereas technical efficiency grows slowly. Thirdly, capital deepening is a major factor leading to technical inefficiency, and it will have an effect on the sustainable growth of China's Northeast.

The organization of this paper is as follows: in Section 2, the methodology of analyzing productivity growth, technical efficiency change and technological progress is outlined; in Section 3, the dependent variable and major independent variables are described; in Section 4, the estimation and the findings from the empirical results are given; lastly, the conclusions and policy suggestions are discussed in the final section.

2. Methodology

2.1 Stochastic Frontier Production for Panel Data

In economic growth theories, Solow (1956) provided the Solow's residual term to measure the change of total factor productivity (TFP). It is not a good measure, however, as a proxy for the change of technological progress, as it is general and includes information unrelated to technological progress. Subsequently, in the 1970s, a useful approach for measuring technological progress, namely the stochastic frontier production function, was independently proposed in Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977).[2] Not until the 1990s, however, was the model of a stochastic frontier production function for panel data contributed by Battese and Coelli (1995).

Here, the stochastic frontier production for panel data is specified as: .

$$Y_{it} = \exp(\beta X_{it} + e_{it}) \tag{1}$$

$$e_{it} = v_{it} + u_{it} \tag{2}$$

where Y_{it} denotes the production of the i^{th} region at the t^{th} time (t = 1, 2, …, T); β is a $k \times 1$ vector of the parameters to be estimated; X_{it} is a $1 \times k$ vector of the value of the inputs of production and other explanatory variables associated with the i^{th} region at the t^{th} time; e_{it} is the error term combining a random term, v_{it}, and the term associated with technical efficiency, u_{it}. In addition, the term v_{it} is assumed a random error, independently distributed

[2] Reviews of this research are provided in Forsund, Lovell and Schmidt (1980), Schmidt (1986), Bauer (1990), Battese (1992), Greene (1993), Wu (1996) and Zhang (2003).

to u_{it}; u_{it} is a non-positive random variable, associated with technical inefficiency of production.[3]

According to Equation (2), the technical efficiency of production for the i^{th} region at t^{th} time can be defined by:

$$TE_{it} = \exp(u_{it}) \tag{3}$$

Manipulating Equations (1), (2), and (3) gives the growth accounting:

$$\dot{Y}_{it} = \beta \dot{X}_{it} + \dot{TC}_{it} + \dot{TE}_{it} \tag{4}$$

where the overdots indicate percentage changes. This equation implies that output growth can be decomposed into three components: the technological progress ($\mathring{TC}_{it}$), input growth ($\beta \mathring{X}_{it}$), and the change in technical efficiency ($\mathring{TE}_{it}$).

Next there is the problem of how to calculate the technical efficiency, TE_{it}, which requires a decomposition of the residual term in Equation (1) into separate estimates of statistical noise and technical inefficiency. The latter, the function of technical efficiency, is defined as (Battese and Coelli, 1995; Cornwell *et al.*, 1990; Fecher and Pestieau, 1993; and Wu, 1995):

$$u_{it} = \mu_{oi} + \mu_{1i}t + \mu_{2i}t^2 + \sum \mu_{jt} Z_{it} + \varepsilon_{it} \tag{5}$$

where Z_{it} is a group of explanatory variables associated with the technical inefficiency of production of a region over time; t is the time; $\mu_{0i}\,(j = 1,..,k)$ are parameters associated with regions; and ε_{it} is a random variable.

How do we estimate the parameters from Equations (1) to (5)? The two-step approach mentioned by Wu (1995) is employed in this paper. In the first step, Equation (1) is estimated by standard panel data approaches with the residuals saved.[4] In the second step, this estimated residual variable is regressed against $t, t^2, \sum Z_{it}$ with a constant term. From this regression, the fitted value η_{it} is obtained. Next, in order to be consistent with the concept of a frontier, η_{it} is normalized so that the estimated level of technical efficiency is non-negative with an upper bound of unity, as follows:

$$TE_{it} = \exp(\eta_{it} - \eta) \tag{6}$$

$$0 \le TE_{it} \le 1$$

where η is the maximum value of η_{it} within a panel.

2.2 *Empirical Application*

In accordance with the preceding sub-section, the empirical model used in this paper is specified as:

$$\ln Y_{it} = \alpha_0 + \alpha_1 \ln K_{it} + \alpha_2 \ln L_{it} + \alpha_3 t + v_{it} + u_{it} \tag{7}$$

---

3 In the literature relating to stochastic frontier production functions, u presents technical inefficiency and is assumed to be a non-negative variable. However, in this paper, u denotes technical efficiency. It is a non-positive variable. Also, in Equation (2) the sign is a plus and not a minus.

4 Random effect models are formulated and estimated by feasible generalized least-squares.

where Y_{it} is the value of output of the i^{th} provision at the t^{th} time; K_{it} and L_{it} are the values of input in the process of production; K_{it} is the input of capital stock, and L_{it} is the input of labor of the i^{th} province over time; v_{it} is a random term and u_{it} is the technical efficiency, in different provinces and at different periods.

What factors, then, determine the change in technical efficiency? In the current literature, two factors are considered to have an impact on the change in technical efficiency. One is the ratio of capital to labor, and this indicator is the measurement of capital-deepening (Sun *et al*., 1990). The other factor is foreign direct investment (FDI). Greater foreign direct investment may bring a more rapid improvement in technological progress and the change in technical efficiency (Coe and Helpman, 1995). Hence, the technical efficiency model can be written as:

$$u_{it} = \mu_{oi} + \mu_{1i}t + \mu_{2i}t^2 + \mu_{3i} fdi / gdp_{it} + \mu_{4i} captal / labor_{it} + \varepsilon_{it} \quad (8)$$

where on the left hand side of the equation u_{it} is the technical efficiency; here, t is the time;[5] fdi/gdp_{it} is the proportion of foreign direct investment in GDP at the t^{th} time in the i^{th} province; $capital/labor_{it}$ is the ratio of capital stock to labor of the i^{th} province at the t^{th} time; $\mu_{ki} (k = 0,1,\ldots,4)$ are the parameters; and ε_{it} is the error term. We can now use this model to measure the change in productivity growth, technical efficiency, and technological progress in the Northeast of China.

3. Data and Empirical Results

3.1 Data Issue

Before estimating the parameters of the models, the data resources and the calculation method of the relevant data will be introduced. Provincial-level panel data for the Northeast of China during the period 1978 to 2005 are used in this study. GDP, FDI, and gross investment data are from the *Statistical Yearbook* for each province. Labor statistics are also from the *Statistical Yearbook* for each province and the remaining data before 1985 are from the *Comprehensive Statistical Data and Materials on 55 Years of New China* (CSD & MNC, 2005). The data for net capital stock are estimated from the gross investment in each year. In order to obtain the data for net capital stock, we calculate net capital stock using the following equation:

$$K_{it} = K_{i,t-1}(1-\delta) + I_{it} \quad (9)$$

where K_{it} and $K_{i,t-1}$ are the net capital stock of the i^{th} province at the t^{th} and t-1^{th} time, respectively; δ is the depreciation rate, and here its value is 5%; I_{it} is the investment for the i^{th} province from 1978 to 2005.[6] Next we construct the deflator of GDP at 1978 constant prices and calculate the value of real GDP, real FDI, and real net capital stock. Table 1 gives the statistical description of the main variables.

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[5] The purpose of adding time into Equation 8 is using the change of time to proxy the effect with time, for example, workers' experience (working experience increasing over time).

[6] In this study, the values of the net capital stock of each province are provided by Zhang Jun *et al*. (2004)

Table 1 Statistical Description of Variables (1978-2005)

Variables	No. Obs.	Mean	Std. Dev.	Min.	Max.
Dependent Variable Real GDP at 1978 constant prices (100 million yuan RMB)	84	596.2	488.4	82	2440.5
Independent Variables Labor (10 thousand persons)	84	1445.6	387.5	645.4	2120.3
Net Capital Stock at 1978 constant prices (100 million yuan RMB)	84	970.2	1021.9	99	5274.8
Real FDI[a] at 1978 constant prices (100 million yuan RMB)	84	76.7	158.4	0	834.28
The ratio of Real Capital to Labor	84	0.600	0.516	0.1	2.488
The ratio of Real FDI to Real GDP	84	0.063	0.086	0	0.35

Note: a) the values of FDI are calculated at the current exchange rate of the RMB to the US dollar.

3.2 Empirical Results

Table 2 gives the estimation results with a Random Effect (RE) model.[7] In column 1 (Table 2), the first stage estimation result is presented. The elasticities of labor and capital are 0.7656 and 0.5752, respectively, and they are both significant at a 1% level of significance. As the sum of these two parameters is more than 1, for the economy of the Northeast of China there are increasing returns to scale in the process of its economic

Table 2 Estimation Results of Frontier Production Functions

Dependent Variable Real GDP (log)	Model 1	Model 2
Explanatory Variables		
Net Capital Stocks (log)	0.5752*** (0.05306)	
Labor (log)	0.7656*** (0.07971)	
Time	0.0064 (0.00499)	-0.0418*** (0.00427)
Time squared		0.00179*** (0.00019)
Ratio of Real FDI to Real GDP		0.9675*** (0.2179)
Ratio of Real Capital to Labor		-0.3340*** (0.06027)
Constant	-3.2339*** (0.37412)	0.2514*** (0.02932)
No. Obs.	84	84
Wald chi-square (3)	5247.93	103.5
Adjusted R-Square		
within	0.9816	0.6129
between	0.9983	0
overall	0.9850	0.5671

Notes: Standard errors in parentheses;
* Significant at 10%; ** significant at 5%; *** significant at 1%.

[7] Wu Yanrui suggests a Random Effect model is suitable as the method to estimate the model. (See: Wu, 1995.)

growth. The elasticity of labor shows that when the input of labor increases by 1%, the output increases by approximately 0.6%. Likewise, the elasticity of capital shows that the output increases 0.7656% with an increase of 1% in the input of capital. In column 2 (Table 2), all coefficients are significant at the 1% level. Furthermore, the ratio of real FDI to real GDP has a positive impact on the technical efficiency, and the ratio of real capital to labor has a negative impact on the technical efficiency.

4. Findings

In accordance with the previous analysis, Table 3 shows the contribution of input factors and productivity of the Northeast of China in different periods. Since 1978 the contribution of capital and labor inputs has continually played an important role in the process of promoting economic growth, and their average contribution percentages are 61.7% and 13.5%, respectively,[8] whereas the contribution percentage of total factor productivity is only 24.8%. At the provincial level during this period Liaoning Province has the highest contribution percentage for capital, namely 69.5%, and Heilongjiang Province has the highest contribution percentage for labor input and total factor productivity (1.5% and 1.2% greater in labor input and total factor productivity, respectively, than for Northeast China).

In addition in this paper, we compare the origins of the change in economic growth before and after 1998. The reason for choosing 1998 as the dividing point is that the deepening of the reform of state-owned enterprises (SOEs) and the Strategy of the Revitalization of the Northeast Old Industrial Base were undertaken around this year. Comparing the two

Table 3 The Contribution of the Productive Factors of the Northeast of China

	Capital	Labor	Total Factor Productivity	Total
The Northeast of China				
1978-2005	61.7%	13.5%	24.8%	100%
1978-1997	61.2%	18.4%	20.4%	100%
1998-2005	60.6%	5%	34.4%	100%
Liaoning				
1978-2005	69.5%	12.4%	18.1%	100%
1978-1997	73.5%	15.7%	10.8%	100%
1998-2005	61.5%	6%	32.5%	100%
Jilin				
1978-2005	53.2%	14.3%	32.5%	100%
1978-1997	68.4%	13.5%	18.1%	100%
1998-2005	63.7%	7.4%	28.9%	100%
Heilongjiang				
1978-2005	59%	15%	26%	100%
1978-1997	68%	11%	21%	100%
1998-2005	58.2%	2.4%	39.4%	100%

Source: All data calculated by the author from the *Statistical Yearbook* for each province, including Liaoning, Jilin, and Heilongjiang provinces (National Bureau of Statistics of China, 2006).

[8] The estimation results in this paper are similar to those in the work of Fu and Wu (2006). In their study, the contribution of TFP is 30%, and the rest-close to 60%-is from the contribution of factor inputs.

periods, economic growth in the Northeast of China has developed increasingly rapidly and the structure of the origin of economic growth has greatly changed. Although factor inputs are still the major origins which promote economic growth, total factor productivity is more important over time. The contribution percentage for total factor productivity goes from 20.4% before 1998 to 34.4% after 1998. This indicates that there is sustainable growth in this region of China, with total factor productivity increasing. Likewise, at the provincial level, the changes for the three provinces are similar.

According to the previous analysis, total factor productivity will play a more important role in the process of Northeast China's growth, and we ought to know what factors promote the rise of total factor productivity. Here, total factor productivity is considered as the combination of two things: one is technological progress and the other is technical efficiency.[9] According to the results of Models 1 and 2 (Table 2) and Equations (4) and (6), we now calculate the values and growth rates of total factor productivity, technological progress and technical efficiency (all results are listed in Tables B1 to B4 in Appendix B).

Figures 1 to 4 show the trends for the total factor productivity, technical efficiency, and technological progress of the Northeast of China. In Figure 1 the change for the whole of the Northeast of China is shown. Since 1978 total factor productivity and technological progress have increasingly fluctuated. After 1990 especially, the growth rate of total factor productivity increases stably, and the average growth rate is 3.78%. Technological progress, however, increases continually until 1995. Moreover, during the period from 1978 to 2005, the graph for the technical efficiency growth rate follows an inverted-"V"-shaped curve. Before 1994, technical efficiency decreased at a rate of -1.26% for each year, yet after 1994, technical efficiency increased gradually. The rate of technical efficiency growth is decreasing, however, and in 2005 particularly, the growth rate became negative.

Figure 2 shows the trends for the total factor productivity of the three Northeastern provinces. In the earlier stages of reform, the growth rate of total factor productivity was irregular, and after 1993 the change of total factor productivity has grown stably. This is the reason for the sustainable growth of each province in the Northeast of China.[10] This is not the entirety of the information for total factor productivity, however, although it is very useful for understanding the structure change in total factor productivity.

The change in the technological progress growth rate is shown in Figure 3. The overall trend for technological progress is similar to that for total factor productivity. In the earlier period of reform, before the early 1990s, the change of technological progress growth rate fluctuated; after Deng Xiaoping's southern tour,[11] the change of the rate of technological

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[9] In current research, some scholars regard total factor productivity as composed of technological progress and the institutional change, while others consider that technological progress and technical efficiency make up total factor productivity. Here, the author thinks there is no contradiction in these two viewpoints. Although the institutional change is different from technical efficiency, sometimes technical efficiency is the performance of the institutional change. There is no contradiction in the definition of total factor productivity.

[10] Total factor productivity has made a great contribution in promoting the economic growth of the three provinces after 1993. The percentage of its contribution is around 30%. (See Table 3)

[11] After the Tiananmen Square Crackdown in 1989, the economic development of China faced a challenge. Some members of the Chinese Communist Party opposed the reform and opening policy. In the earlier 1990s (18-21 January 1992), Deng Xiaoping decided to make a tour of southern China, including Shenzhen, Shanghai, and Zhuhai, etc. In the process of the tour, he gave many important talks and confirmed the achievements of reform. Hence, after 1992, China obtained a new opportunity for development.

progress growth increased continually.

In Figure 4 the change of technical efficiency of the three Northeastern provinces is shown. Before 1990, the change in technical efficiency followed a decreasing trend, and the average growth rates for each province were -2.57% (in Liaoning Province), -2.11% (in Jilin Province), and -2.48% (in Heilongjiang Province), respectively. After 1990, although the change in technical efficiency of each province increased rapidly, there were some differences among the three provinces.

The period after 1990 can be divided into three sub-stages according to the trend in technical efficiency growth. In the first stage (1990-1994), the technical efficiency growth for Heilongjiang Province was the fastest among the three provinces, and its average growth rate reached 1.38%, while the average growth rates in technical efficiency for Jilin and Liaoning provinces were 1.26% and 1.22%, respectively. From 1995 to 2001, the second sub-stage, the technical efficiency growth for Jilin and Heilongjiang provinces slowed, and the average growth rates for the two provinces were 0.7% and 0.9%, respectively. The performance in technical efficiency of Liaoning Province, however, was conspicuous and maintained a constant increase with an average growth rate of 1.67%. In the last stage, from 2002 to 2005, the technical efficiency for the three provinces with the exception of Heilongjiang Province showed a decreasing trend. This change should receive our attention. This phenomenon indicates that the decreasing of the technical efficiency of Liaoning and Jilin provinces will affect the sustainable growth of the Northeast of China. Meanwhile, the economic growth of Heilongjiang Province may achieve a better performance than the other provinces in the Northeast of China.

Figure 1
The Growth Rate of Technical Efficiency, Technological Progress and Total Factor Productivity of the Northeast of China, 1979-2005

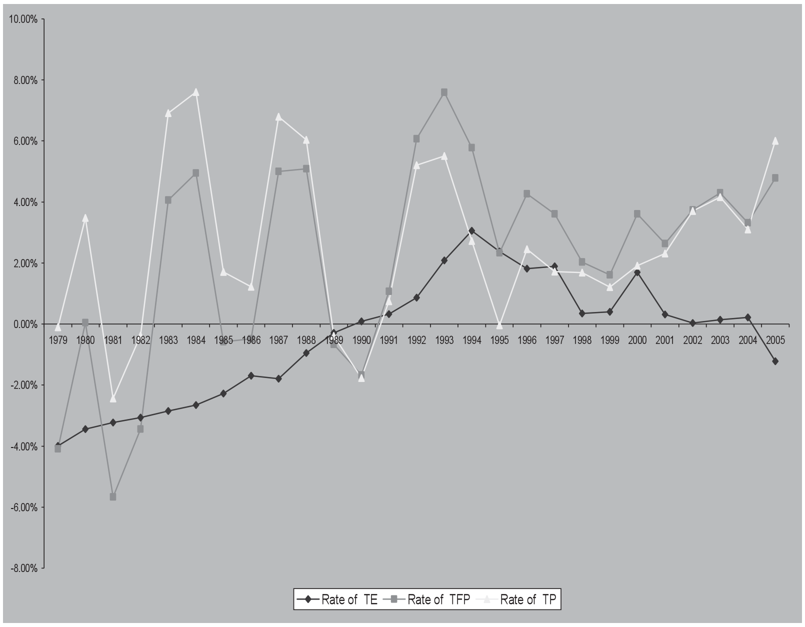


Figure 2
The Growth Rate of Total Factor Productivity of the Three Provinces of the Northeast of China, 1979-2005

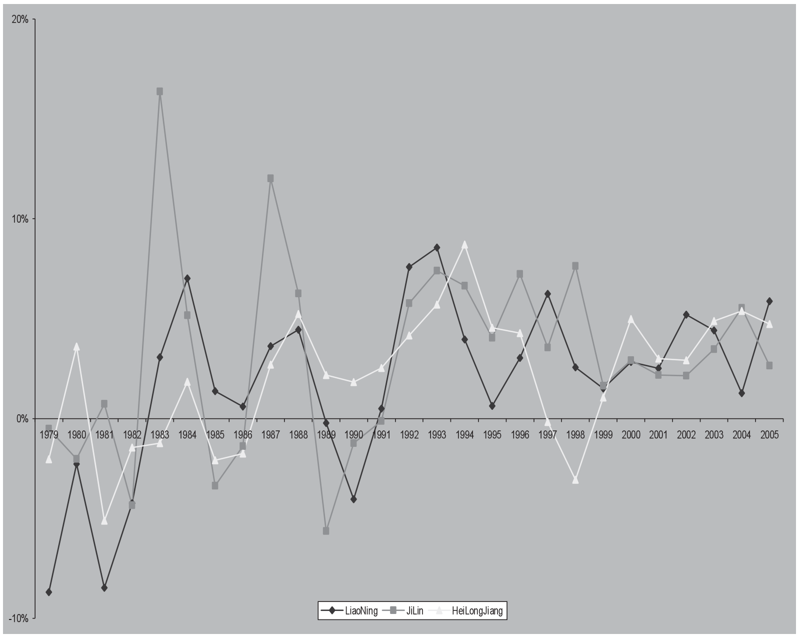


Figure 3
The Growth Rate of Technological Progress of the Three Provinces of the Northeast of China, 1979-2005

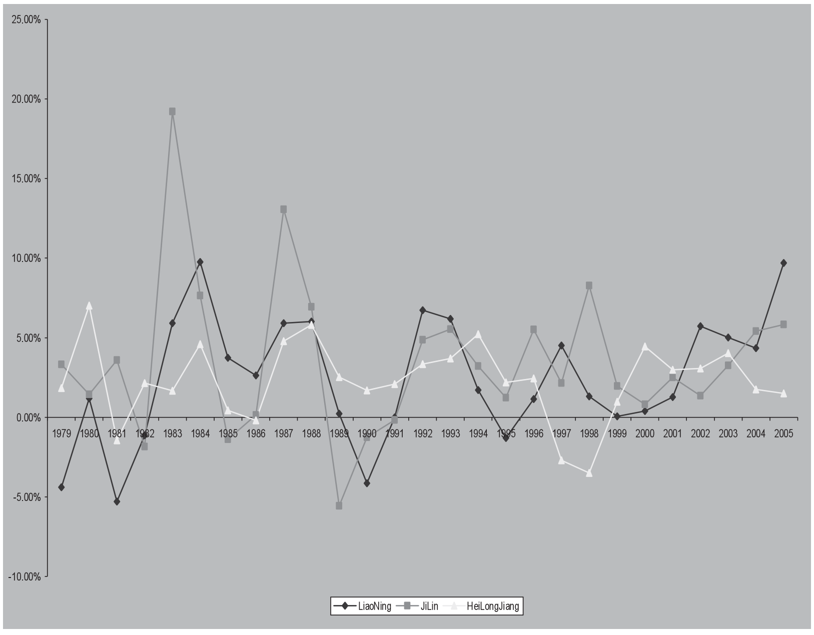
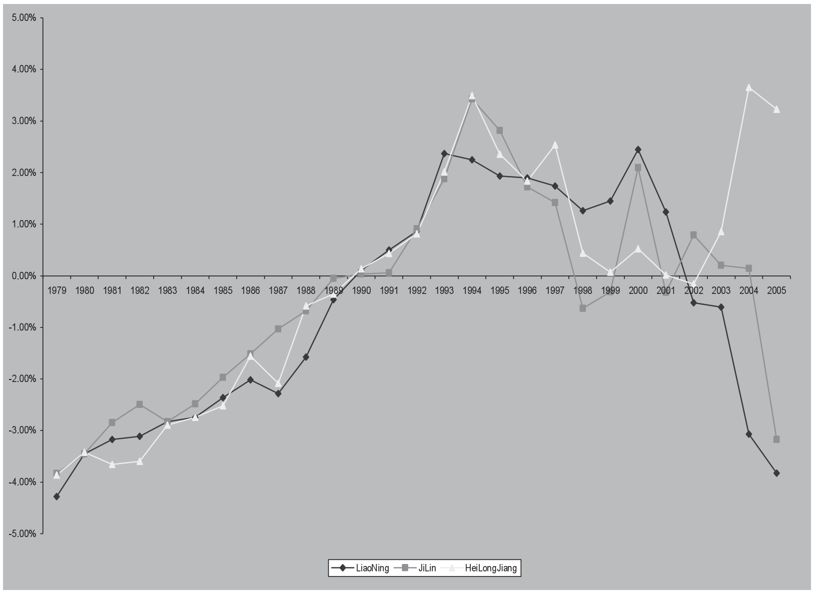


Figure 4
The Growth Rate of Technical Efficiency of the Three Provinces of the Northeast of China, 1979-2005



5. Concluding Remarks

The region of the Northeast of China has played an important role in the process of the economic development of Northeast Asia over time. Recently in particular, with the deepening of the reform of state-owned enterprises (SOEs) and the undertaking of the Strategy of the Revitalization of the Northeast Old Industrial Base, the economy of the Northeast of China has been flourishing and economic growth has gone on increasing with the higher rates of growth. Hence it was necessary to analyze whether the economic growth of Northeast China is sustainable or not.

In this paper, we applied the stochastic frontier production function approach to analyze the economic growth of Northeast China. According to our estimation results, we find that the contributions of factor inputs are decreasing gradually, and the contribution of total factor productivity plays a more important role over time. Moreover, in this study, productivity growth was defined as the sum of technical efficiency change and technological progress. Our main finding is that the technological progress of the Northeast of China has grown continually, whereas the technical efficiency has grown slowly, and a decreasing trend in technical efficiency has been shown for the two provinces of Liaoning and Jilin, in particular. Technical inefficiency may affect the sustainable growth of Northeast China in the future. Moreover, we found that foreign direct investment and the ratio of capital to labor have an impact on the change in technical efficiency. Foreign direct investment had a positive effect on technical efficiency, and capital deepening is negative regarding the change in technical efficiency.

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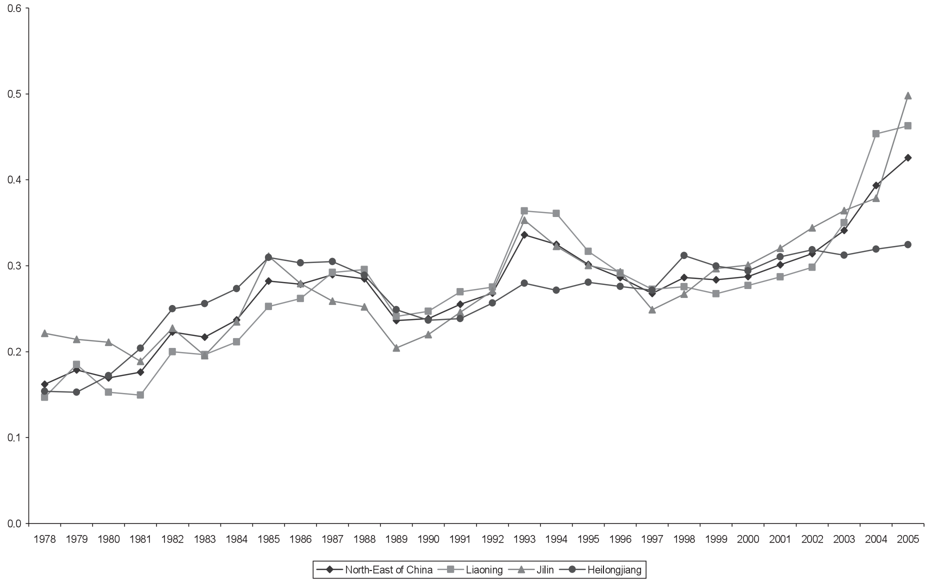
Appendix A:

Figure A1
The ratio of Investment to GDP at Current Prices in the Northeast of China (1978-2005)



Source: All data calculated by the author from the *Statistical Yearbook* for each province, including Liaoning, Jilin, and Heilongjiang provinces (National Bureau of Statistics of China, 2006).

Table A1
Average Growth Rate of the Economy in the Northeast of China

	Northeast of China		Liaoning	
	Curr. (%)	Con. (%)	Curr. (%)	Con. (%)
GDP Growth Rate				
(1978-2005)	N.A.	8.9	N.A.	9.2
(1993-2005)	N.A.	10	N.A.	10.1
GDP per Capita				
(1978-2005)	13.4	8.0	13.3	8.3
(1993-2005)	14.0	9.4	13.7	9.7
GDP per Worker				
(1978-2005)	11.9	6.7	12.1	7.2
(1993-2005)	13.8	9.2	13.4	9.5
	Jilin		**Heilongjiang**	
	Curr. (%)	Con. (%)	Curr. (%)	Con. (%)
GDP Growth Rate				
(1978-2005)	N.A.	9.7	N.A.	8.0
(1993-2005)	N.A.	10.3	N.A.	9.4
GDP per Capita				
(1978-2005)	14.3	8.8	13	7.2
(1993-2005)	14.9	9.6	14.2	8.9
GDP per Worker				
(1978-2005)	12.6	7.2	11.5	5.9
(1993-2005)	15.6	10.4	13.3	8.0

Note: Curr. = Current Prices; Con. = Constant Prices (1978 = 100); N.A. = Not available. All data are taken from the *Liaoning Statistical Yearbook*, the *Jilin Statistical Yearbook*, and the *Heilongjiang Statistical Yearbook* (National Bureau of Statistics of China, 2006).

Appendix B:

Table B1
Estimates of the Technical Efficiency of the Northeast of China, 1978-2005

	Liaoning	Jilin	Heilongjiang	Northeast of China
1978	1.000	0.982	0.981	0.988
1979	0.957	0.945	0.943	0.948
1980	0.924	0.912	0.911	0.916
1981	0.895	0.886	0.877	0.886
1982	0.867	0.864	0.846	0.859
1983	0.842	0.840	0.821	0.834
1984	0.819	0.819	0.799	0.812
1985	0.800	0.803	0.779	0.794
1986	0.784	0.791	0.767	0.780
1987	0.766	0.782	0.751	0.766
1988	0.754	0.777	0.746	0.759
1989	0.750	0.777	0.744	0.757
1990	0.751	0.777	0.745	0.758
1991	0.755	0.777	0.748	0.760
1992	0.761	0.785	0.754	0.767
1993	0.780	0.799	0.769	0.783
1994	0.797	0.827	0.796	0.807
1995	0.812	0.850	0.815	0.826
1996	0.828	0.865	0.830	0.841
1997	0.842	0.877	0.851	0.857
1998	0.853	0.871	0.854	0.860
1999	0.865	0.869	0.855	0.863
2000	0.886	0.887	0.860	0.878
2001	0.897	0.884	0.860	0.880
2002	0.893	0.891	0.858	0.881
2003	0.887	0.893	0.866	0.882
2004	0.860	0.894	0.897	0.884
2005	0.827	0.866	0.926	0.873

Note: The Northeast represents the arithmetic mean.

Table B2
Rates of Technical Efficiency Growth, 1978-2005

	Liaoning	Jilin	Heilongjiang	Northeast of China
1978	N.A.	N.A.	N.A.	N.A.
1979	-4.28%	-3.83%	-3.86%	-3.99%
1980	-3.45%	-3.45%	-3.42%	-3.44%
1981	-3.17%	-2.85%	-3.65%	-3.22%
1982	-3.11%	-2.50%	-3.60%	-3.07%
1983	-2.83%	-2.83%	-2.90%	-2.85%
1984	-2.74%	-2.48%	-2.74%	-2.65%
1985	-2.36%	-1.97%	-2.52%	-2.28%
1986	-2.02%	-1.52%	-1.56%	-1.70%
1987	-2.29%	-1.03%	-2.08%	-1.79%
1988	-1.58%	-0.68%	-0.58%	-0.95%
1989	-0.46%	-0.05%	-0.35%	-0.29%
1990	0.11%	0.03%	0.14%	0.09%
1991	0.50%	0.06%	0.43%	0.33%
1992	0.86%	0.91%	0.81%	0.86%
1993	2.37%	1.88%	2.01%	2.08%
1994	2.25%	3.43%	3.49%	3.06%
1995	1.93%	2.81%	2.36%	2.37%
1996	1.89%	1.72%	1.84%	1.82%
1997	1.74%	1.42%	2.54%	1.89%
1998	1.26%	-0.63%	0.44%	0.34%
1999	1.45%	-0.31%	0.07%	0.40%
2000	2.45%	2.10%	0.53%	1.70%
2001	1.24%	-0.32%	0.01%	0.31%
2002	-0.53%	0.79%	-0.16%	0.03%
2003	-0.61%	0.20%	0.86%	0.14%
2004	-3.07%	0.14%	3.65%	0.21%
2005	-3.83%	-3.17%	3.22%	-1.22%

Notes: The Northeast represents the arithmetic mean. N.A. = Not available.

Table B3
Rates of Total Factor Productivity Growth, 1978-2005

	Liaoning	Jilin	Heilongjiang	Northeast of China
1978	N.A.	N.A.	N.A.	N.A.
1979	-8.68%	-0.52%	-2.03%	-4.10%
1980	-2.27%	-2.01%	3.61%	0.04%
1981	-8.47%	0.74%	-5.11%	-5.66%
1982	-4.25%	-4.34%	-1.45%	-3.44%
1983	3.07%	16.38%	-1.22%	4.06%
1984	7.02%	5.17%	1.85%	4.95%
1985	1.38%	-3.36%	-2.08%	-0.58%
1986	0.61%	-1.38%	-1.75%	-0.48%
1987	3.62%	12.02%	2.71%	5.00%
1988	4.45%	6.26%	5.23%	5.09%
1989	-0.23%	-5.63%	2.18%	-0.67%
1990	-4.04%	-1.23%	1.83%	-1.67%
1991	0.49%	-0.12%	2.53%	1.07%
1992	7.59%	5.78%	4.16%	6.07%
1993	8.56%	7.40%	5.70%	7.59%
1994	3.95%	6.64%	8.71%	5.78%
1995	0.63%	4.05%	4.54%	2.33%
1996	3.04%	7.24%	4.27%	4.27%
1997	6.24%	3.56%	-0.17%	3.60%
1998	2.57%	7.64%	-3.06%	2.03%
1999	1.50%	1.65%	1.05%	1.60%
2000	2.84%	2.92%	4.98%	3.61%
2001	2.51%	2.17%	3.00%	2.63%
2002	5.21%	2.14%	2.91%	3.74%
2003	4.41%	3.46%	4.88%	4.30%
2004	1.26%	5.54%	5.39%	3.32%
2005	5.88%	2.65%	4.72%	4.78%

Notes: The Northeast represents the arithmetic mean. N.A. = Not available.

Table B4
Rates of Technological Progress Growth, 1978-2005

	Liaoning	Jilin	Heilongjiang	Northeast of China
1978	N.A.	N.A.	N.A.	N.A.
1979	-4.40%	3.32%	1.83%	-0.10%
1980	1.18%	1.44%	7.03%	3.48%
1981	-5.30%	3.58%	-1.46%	-2.44%
1982	-1.13%	-1.84%	2.15%	-0.38%
1983	5.90%	19.21%	1.67%	6.91%
1984	9.76%	7.65%	4.59%	7.60%
1985	3.74%	-1.39%	0.44%	1.70%
1986	2.62%	0.13%	-0.20%	1.22%
1987	5.91%	13.05%	4.79%	6.80%
1988	6.02%	6.93%	5.82%	6.04%
1989	0.23%	-5.58%	2.53%	-0.39%
1990	-4.15%	-1.26%	1.69%	-1.77%
1991	-0.01%	-0.18%	2.09%	0.74%
1992	6.73%	4.87%	3.35%	5.21%
1993	6.19%	5.53%	3.69%	5.51%
1994	1.70%	3.21%	5.22%	2.72%
1995	-1.30%	1.23%	2.19%	-0.04%
1996	1.14%	5.52%	2.44%	2.45%
1997	4.50%	2.14%	-2.71%	1.71%
1998	1.31%	8.27%	-3.50%	1.69%
1999	0.05%	1.96%	0.98%	1.21%
2000	0.39%	0.82%	4.45%	1.92%
2001	1.27%	2.50%	2.99%	2.32%
2002	5.73%	1.35%	3.07%	3.71%
2003	5.02%	3.26%	4.03%	4.15%
2004	4.33%	5.40%	1.74%	3.10%
2005	9.70%	5.82%	1.50%	6.00%

Notes: The Northeast represents the arithmetic mean. N.A. = Not available.

Mongolia's International Trade: The Impact of Its Geographical Location

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Abstract

This paper examines the influence of Mongolia's landlocked location between Russia and China on the country's international trade patterns through the use of an augmented gravity model. The results are basically consistent with the prediction of the gravity model with some unexpected results for per capita GDP and the WTO dummy. Further, this paper discusses relevant policy implications.

KEYWORDS: Mongolia; international trade; trade patterns and determinants; geographic location; gravity model

JEL Classification: F14, F15, O18, R40

1. Introduction

Mongolia's geographical location is not favorable for international trade, as it is landlocked and 1,724 kilometers away from the nearest seaport.[1] Moreover, its borders are with China and Russia only. Nonetheless, after 1990, when Mongolia transitioned from a centrally-oriented economy to a market-based open economy, the country has attempted to reform its trade structure and to diversify its trading partners, a reform that was accelerated after Mongolia joined the World Trade Organization (WTO) in 1997. As a result the country's average tariff rate has been significantly reduced from 18% to 5% since then (Batsaikhan, 2009). Additionally, Mongolia signed bilateral trade and economic cooperation agreements with several countries including Russia, China, the United States, Canada, Indonesia, and Malaysia, and regions such as the European Union (EU) (Enkhbayar, Sh., 2005). Furthermore, the United States, Japan, the EU, New Zealand, Norway, Switzerland, and Turkey have offered Mongolia a GSP (Generalized System of Preferences) exemption,[2] mainly for textiles and garment products (UNCTAD, 2008).

The goal of this study is to identify the determinants of Mongolia's trade flows using the data of the country's bilateral trade[3] with 59 countries between 1995 and 2008. The main tools of investigation are augmented gravity models. We follow the so-called N × 1 approach first used by Wall (1999), and extended by Sohn (2005), who argued that

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2 "Generalized System of Preferences (GSP) is a preferential tariff system extended by developed countries (also known as preference-giving countries or donor countries) to developing countries (also known as preference-receiving countries or beneficiary countries). [GSP] involves reduced tariffs or duty-free entry of eligible products exported by beneficiary countries to the markets of donor countries" (Export Inspection Office of India, 2010).

3 These data are from the IMF DOT database.

"the N × N gravity models deal with symmetric trade policies that are equally applicable to all N countries such as free trade areas, whereas the N × 1 model can deal with country-specific trade policy measures" (Sohn, 2005, p. 1).

Furthermore, we attempt to capture Mongolia's unique geographical location. First, we pay extra attention to distance. A large number of gravity model studies use sea-route distances between seaports. However, in the case of a landlocked country like Mongolia, where access to the sea is relatively expensive, distance should be measured using a different method (see Appendix 1 for the detailed methodology for measuring distances). Secondly, we focus on China and Russia as Mongolia shares borders with these countries only. Therefore, they remain Mongolia's top two trading partners even though Mongolia has other trading partners.

This paper is comprised of five sections. The background analysis of Mongolia's economy and trade is given in Section 2. Next, the methodology and data used in the empirical analysis are introduced in Section 3, while the regression analyses and empirical results are presented in Section 4. Finally, conclusions are given in Section 5.

2. Mongolia's International Trade Overview

Mongolia's trade volume has increased, and trade flow has diversified since the country initiated reforms in 1990 and joined the WTO in 1997; however, its landlocked trade is mostly carried out with only a few neighboring countries.

Table 1 shows that China has become Mongolia's single largest export market by far, while Russia's share has continuously declined. The United Kingdom, the United States, Canada, the ROK, and Japan follow but with considerably smaller shares. In terms of export products, mining products such as gold, copper, and other minerals comprised approximately 80% of Mongolia's exports on average (NSO, 2009); furthermore, manufactured goods that include those of livestock origin, raw materials, and miscellaneous manufactured articles like textiles and garments represented approximately 20% of Mongolia's exports. As for import markets, Russia and China constitute the largest proportion; Russia, in fact, supplies almost all of Mongolia's petroleum products (92% as of 2007) (UN-COMTRADE, 2009).

Table 1 Export Share for Mongolia's Trading Partners between 1996 and 2007

Trading partner	1996	1998	2001	2004	2007
China	19.1%	29.3%	44.4%	47.8%	72.8%
Russia	20.6%	11.8%	8.6%	2.1%	2.7%
United Kingdom	4.5%	3.7%	2.4%	15.7%	0.6%
USA	4.2%	8.5%	27.7%	17.9%	4.8%
Canada	0.0%	0.0%	0.2%	1.7%	11.0%
Italy	2.5%	2.9%	3.2%	2.0%	2.8%
Korea, Republic of	8.0%	9.6%	3.9%	0.9%	0.5%
Japan	8.2%	3.7%	3.0%	3.9%	0.7%
Germany	0.0%	0.0%	0.4%	1.3%	0.7%
Hong Kong	0.0%	0.0%	1.3%	0.1%	0.1%
France	0.0%	0.0%	0.1%	1.7%	0.7%
Others	32.9%	30.5%	4.8%	4.9%	2.6%

Source: IMF DOT database

Table 2 Import Share for Mongolia's Trading Partners between 1996 and 2007

Trading partner	1996	1998	2001	2004	2007
Russia	34.4%	29.8%	35.4%	33.3%	29.1%
China	14.6%	11.6%	18.8%	23.6%	32.1%
Japan	17.3%	11.8%	8.8%	7.4%	7.5%
Korea, Republic of	4.0%	7.5%	9.1%	6.0%	3.6%
Germany	4.8%	5.2%	4.8%	3.3%	3.7%
Singapore	3.0%	3.4%	1.6%	1.5%	1.9%
USA	2.5%	7.2%	2.3%	4.6%	1.3%
Kazakhstan	0.2%	0.7%	3.3%	2.6%	1.6%
Hong Kong	0.0%	0.0%	2.5%	1.5%	0.5%
France	0.3%	5.3%	1.0%	1.4%	0.8%
Ukraine	0.6%	0.3%	0.4%	1.5%	1.3%
Italy	5.1%	0.7%	0.5%	0.3%	0.4%
Others	15.2%	22.9%	13.4%	12.9%	10.6%

Source: IMF DOT database

3. Model and Data

3.1. The Gravity Equation

In this study, the augmented gravity model by Rose (2002) is applied. In addition to the standard explanatory variables in the gravity-model literature, we used exchange rate volatility, foreign direct investment, a trade freedom index, trade openness, and other dummy variables. The equation is as follows:

$$\begin{aligned} \ln TRADE_{ijt} &= \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln GDPperCap_{it} + \beta_4 \ln GDPperCap_{jt} \\ &+ \beta_5 \ln RER_{ijt} + \beta_6 \ln FDI_{it} + \beta_7 \ln Openness_{it} + \beta_8 \ln Openness_{jt} + \beta_9 \ln DIST_{ij} \\ &+ \beta_{10} \ln TFI_{it} + \beta_{11} \ln TFI_{jt} + \beta_{12} DUMMY_{jt} + \varepsilon_{ijt} \end{aligned} \quad (1)$$

where the respective variables are denoted thus:

$TRADE_{ijt}$	Bilateral trade flow (total trade, exports or imports) between Mongolia (*i*) and its trading partner (*j*) in year *t*
GDP_{it}	Gross domestic product of Mongolia (*i*) in year *t*
GDP_{jt}	Gross domestic product of the trading partner (*j*) in year *t*
$GDPperCap_{it}$	Gross domestic product per capita of Mongolia (*i*) in year *t*
$GDPperCap_{jt}$	Gross domestic product per capita of the trading partner (*j*) in year *t*
RER_{jt}	Real exchange rate of Mongolian currency against the trading partner's (*j*) currency in year *t*
FDI_{it}	Foreign direct investment to Mongolia (*i*) in year *t*
$Openness_{it}$	Trade openness ratio of Mongolia (*i*) in year *t*
Opennessjt	Trade openness ratio of the trading partner (*j*) in year *t*

$DIST_j$	Distance (transport distance and trade cost) between Mongolia and the trading partner (j)
TFI_{it}	Trade freedom index of Mongolia (i) in year t
TFI_{jt}	Trade freedom index of the trading partner (j) in year t
$DUMMY_j$	Set of dummy variables related to the trading partner (j), including adjacency and WTO membership
ε_{ijt}	Residuals

Among the explanatory variables, GDP serves as a proxy for the economic size of each of a pair of countries, both in terms of production capacity and markets. Big countries with a large production capacity are more likely to achieve economies of scale and increase their exports on the basis of comparative advantage. Furthermore, their large domestic markets attract greater imports. Therefore, an increase in GDP is expected to increase bilateral trade volumes. On the other hand, GDP per capita measures the income level and purchasing ability of a trading partner. According to Bergstrand (1989), the sign of this coefficient depends on whether trading goods are labor intensive or capital intensive. The real exchange rates of the currency of a trading partner against the Mongolian togrog are examined, as the exchange rate is one of the main factors influencing international trade (Kandogan, 2004). The coefficient of the real exchange rate is expected to be negative for exports and positive for imports because when a currency depreciates in real terms, prices of domestic goods become cheaper than foreign goods, and then exports increase. In contrast, when a currency appreciates, imports increase. We also examined the foreign direct investment (FDI) of Mongolia; its expected sign is positive. The distance variable was added, representing trade resistance factors, transport costs, transport time, cultural unfamiliarity, and market access, and its expected sign is negative (see Appendix 1 for detailed information on the distances used in this study).

Apart from distance, both tariff and non-tariff barriers restrict world trade. In order to study these barriers, the trade freedom index calculated annually by the Heritage Foundation, on the basis of a country's tariff and non-tariff barriers, is also included in the examination. A value of 100 implies perfectly free trade, whereas a value of zero implies the opposite. Therefore, the coefficient sign of the index is expected to be positive, meaning that countries with a freer trade policy than others tend to trade more. In addition, a trade openness measurement, which is derived from the ratio of trade to GDP, was tested with a hypothesis that the more an economy is open, the more it trades with Mongolia, and vice versa. Furthermore, the WTO member dummy variable, which takes the value of one if a trading partner is a member of the WTO for a given observation and of zero otherwise, is used to evaluate Mongolia's involvement in the WTO. The sign of this variable is expected to be positive, which means that Mongolia tends to trade more if a partner is a member of the WTO. Finally, the adjacency dummy variable (it takes the value of one if the partner is Russia or China, and zero otherwise) identifies the deviations from the neighboring trading partners on the trade flow from other trading partners.

The general methodology used in this analysis was previously employed by Wall (1999) and applied on a single country's bilateral trade data to analyze its particular trade patterns. Analyses were performed separately on total trade, exports, and imports to detect the different effects of determinants on trade flow. In addition, in order to check the robustness of the results, a sensitivity analysis was conducted by running regressions for all models excluding Mongolia’s trade with Russia and China. If the two results are significantly different, it can be concluded that Mongolia’s geographical location between Russia and China has resulted in a distortion of its trade patterns.

3.2. Data

This study used bilateral trade data to analyze trade between Mongolia and its 59 main trading partners from 1995 to 2008. The data on bilateral trade flows (imports, exports, and total trade turnover) were obtained from the IMF Direction of Trade Statistics (DOT) database. The data for GDP, per capita GDP, foreign direct investment (FDI), trade openness, and real exchange rate were obtained from the World Development Indicators database. Trade freedom indexes were downloaded from the Index of Economic Freedom produced by the Heritage Foundation[4] and the Wall Street Journal. The transportation distance variable was calculated by the authors on the basis of the time-cost analysis on Northeast Asian railroads by UNESCAP and the ship-voyage distance calculator at portworld.com (see Appendix 1: Calculated Distances and the Calculation Procedure thereof).

3.3. Methodology

Before running regressions, observations with a trade value of zero were adjusted by changing this into a very small number (0.0001), following the method used by Kalbasi (2001). This method was recommended by several researchers such as Anderson and Wincoop (2003) and Butt (2008).

In the preliminary regressions, the GDP per capita and FDI inflows in Mongolia were highly correlated with its GDP, causing collinearity problems (see Appendix 2: Correlation Matrix and Variance Inflation Factor Estimation of Explanatory Variables). Consequently these variables were not considered for further analysis. To prevent multicollinearity, variance inflation factors (VIFs) were estimated for each regression and the means of the VIFs for all ordinary least squares (OLS) regressions were found to be lower than five.

This study adopts the pooled OLS instead of fixed or random effects to analyze the panel data. Initially, we conducted the Hausman Test and found that the fixed effect model is superior to the random effect model. Nevertheless, the fixed effect model had two problems. First, it did not capture the effect for distance and adjacency for time-invariant reasons. Second, the estimated coefficients were somewhat distorted[5] due presumably to multicollinearity. Consequently, it would be safe to use the pooled OLS approach in spite of the potential problem of biased estimators. Additionally, to consider heteroskedasticity, robust standard errors are used throughout all of the regressions.

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[4] For a detailed explanation of the Index of Economic Freedom, see http://www.heritage.org/Index/Default.aspx

[5] Total trade elasticity with respect to the trading partner's GDP in the fixed effect model is more than 10 times larger than that of the pooled OLS model. For example, a 1% increase in a trading partner's GDP results means an approximately 15% increase of Mongolia's total trade flow, which is not very realistic.

Table 3 Regression Results for Mongolia's Total Trade

	Model (1)			Model (2)			Model (3)		
Explanatory variables	Coef.	*t-statistic*		Coef	*t-statistic*		Coef	*t-statistic*	
log(GDP - Partners)	1.37	15.37	***	1.31	13.84	***	1.34	13.93	***
log(GDP - Mongolia)	0.71	3.74	***	0.72	3.77	***	0.76	3.88	***
log(GDP per Capita - Partners)	-0.03	-0.19		-0.02	-0.16		-0.07	-0.50	
log(Distance)	-2.02	-13.41	***	-1.82	-10.15	***	-1.88	-10.02	***
log(Openness - Partners)	1.29	6.20	***	1.28	6.17	***	1.31	6.23	***
log(Openness - Mongolia)	4.01	3.24	***	3.95	3.20	***	4.07	3.21	***
log(Freedom - Partners)	1.50	2.61	***	1.74	2.81	***	1.85	2.77	***
log(Freedom - Mongolia)	-1.06	-0.67		-1.04	-0.66		-1.00	-0.61	
log(RER)	-0.07	-1.33		-0.04	-0.83		-0.06	-1.04	
WTO - dummy	-1.19	-3.07	***	-1.03	-2.53	**	-0.87	-1.99	**
Adjacency - dummy				1.46	2.70	***			
Constant	-28.82	-4.73	***	-30.89	-5.05	***	-32.79	-5.01	***
No. of observations	728			728			702		
Adj R-squared		0.47			0.48			0.42	

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.
Pooled OLS regression
Model (1): All countries; without adjacency dummy
Model (2): Full set model (all countries, all variables)
Model (3): Excluding China and Russia

4. Results and Discussion

The regression results for Mongolia's total trade are shown in Table 3. First, as predicted by the gravity model, the GDP of trading partners and Mongolia are significant at the 1% level with a positive sign, and distance variable is significant with a negative and relatively large[6] coefficient, implying that distance related barriers and costs are higher in case of Mongolia's international trade. With regard to statistically significant factors, trade openness and the trade freedom index have positive effects on Mongolia's trade, a finding that is also consistent with the expected results. The results for per capita GDP and the WTO dummy are a bit complicated, however; their signs are negative. The negative sign of per capita GDP is presumably because of Mongolia's predominant trade with China, whose per capita income is still low. Regarding the WTO dummy, a possible reason could be that Mongolia has a stronger economic connection with non-WTO member nations than those under the WTO.

The adjacency dummy variable, which represents Russia and China, is added in the second equation for OLS regressions and is estimated to be significant at the 1% level. In particular, the estimate of 1.46 for the adjacency dummy implies that Mongolia's trade flows with Russia and China are more than 4.3 (< exp(1.46)) times larger than those with other countries. As Russia and China are very important to Mongolia's trade, we ran regressions excluding these two conutries to check the roboustness of the gravity model, that is, to determine whether or not the gravity model would still be consistent. The regression results

6 As Sohn (2005) mentioned in his paper, most studies found distance variable with the coefficient around -0.76 - 0.94.

Table 4 Regression Results for Mongolia's Exports and Imports

	Exports						Imports					
	Model (1)			Model (2)			Model (1)			Model (2)		
Explanatory variables	Coef.	*t*-statistic		Coef.	*t*-statistic		Coef.	*t*-statistic		Coef.	*t*-statistic	
log(GDP - Partners)	1.91	16.25	***	1.82	14.70	***	1.32	13.28	***	1.27	11.98	***
log(GDP - Mongolia)	0.23	0.76		0.23	0.77		0.74	3.31	***	0.74	3.33	***
log(GDP per Capita - Partners)	0.54	3.07	***	0.55	3.10	***	-0.15	-1.01		-0.15	-0.98	
log(Distance)	-2.29	-12.06	***	-1.96	-9.13	***	-2.12	-12.31	***	-1.93	-9.85	***
log(Openness - Partners)	1.52	5.40	***	1.51	5.41	***	1.34	6.12	***	1.33	6.04	***
log(Openness- Mongolia)	3.65	2.49	**	3.56	2.45	**	3.01	2.24	**	2.96	2.21	**
log(Freedom - Partners)	-0.91	-1.53		-0.51	-0.77		1.61	2.72	***	1.84	2.87	***
log(Freedom - Mongolia)	-2.03	-1.14		-2.01	-1.14		0.12	0.07		0.14	0.08	
log(RER)	-0.22	-4.45	***	-0.18	-3.60	***	-0.03	-0.55		-0.01	-0.17	
WTO - dummy	-2.22	-5.32	***	-1.96	-4.60	***	-0.70	-1.50		-0.55	-1.11	
Adjacency - dummy				2.44	4.31	***				1.38	2.19	**
Constant	-14.79	-1.97	*	-18.23	-2.39	**	-29.94	-4.67	***	-31.90	-4.95	***
Observations	729			729			731			731		
Adj R-squared		0.55			0.55			0.40			0.41	

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.
Model (1): Without adjacency dummy
Model (2): Including adjacency dummy
Unlike in Table 3, we did not provide the results in the case where we excluded China and Russia. In fact, these results are almost the same as the results for Model (2).

do not show a considerable difference in comparison with the previous results in terms of coefficient significance, coefficient values, and R-squares, confirming the robustness of the model.

Table 4 provides the regression results of export and import flows. These results are slightly different from those for total trade flows. For instance, Mongolia's GDP is estimated to be insignificant in the regression of export flow, and a trading partner's GDP per capita is estimated to be significant with positive sign in the export regression, implying that Mongolia tends to export to wealthier countries even though export flow does not correlate Mongolia's economic growth. While it was not significant in all the models of total trade flow, the real exchange rate (RER) is estimated significant with negative sign. It reveals that Mongolia's export is vulnerable to exchange rate fluctuation. The adjacency dummy is estimated to have a positive sign and is significant at the 1% level on the export side. In comparison with the results for total trade, this coefficient is much larger, indicating that Mongolia's exports go mainly to its two neighbors (China and Russia); thus, Mongolia is highly dependent on their markets.

5. Conclusion

The determinants of trade flows between Mongolia and its trading partners were investigated in this paper, and the influence of Mongolia's geographical location between Russia and China on its international trade patterns was also examined. We employed an augmented gravity model with panel data from 1995 to 2008 and econometric tools such as pooled OLS and fixed effect regressions. The empirical results were consistent with the implication of the gravity model, and the main variables were derived as expected, with only a few exceptions, including a negative sign for GDP per capita and the WTO dummy.

The impact of Mongolia's geographical location between China and Russia on its trade flow was analyzed in two different ways in this paper. First, an adjacency variable was introduced to observe the deviations between other trading partners and Mongolia's two neighbors. Second, we checked the robustness of the results by running regressions that omitted Russia and China. The adjacency dummy showed a positive relationship with Mongolia's trade and the gravity model was robust irrespective of the inclusion of the two influential neighboring countries of Mongolia.The result implies that Mongolia's unique geographical location between two giant conutries does not distort its international trade pattern.

On the basis of the above empirical results, several policy implications can be drawn. First, Mongolia's trade policy may need to focus on the irresponsiveness of trade to its main factors, such as membership of WTO and Trade freedom of a partner and Mongolia itself, which makes Mongolia's trade sufficiently insensitive to these key factors to take advantage of them or to lessen the risks caused by those factors. In particular, the policy should emphasize the Mongolia's export because it is vulnerable to exchange rate fluctuation, not responsive to partner's trade freedom factor, highly dependent on nearby countries namely two neighbors and not correlated with Mongolia's economic growth.

In contrast, this paper has also revealed some opportunities that could possibly be used as a solution for the abovementioned problems. Mongolia has an untapped potential to trade with high-income economies, especially in terms of import, by trading more advanced and qualified products. In addition, Mongolia can expand its trade to more distant countries by lessening the landlockedness problem and reducing transportation costs and other barriers, and diversifying its trading partners.

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APPENDICES

Appendix 1: Calculated Distances and the Calculation Procedure thereof

Trading partner	Starting point	Point(s) en route and final destination	Distance between points en route (km)	Total distance (km)	Mode
China	Ulaanbaatar	Beijing	1,573	1,573.0	rail
Russia	Ulaanbaatar	Weighted	5,021	5,021.0	rail
Argentina	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Buenos Aires (AR BUE)	21,170	22,894.0	sea
Australia	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Sydney (AU SYD)	9,273	10,997.0	sea
Austria	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Venice (Italy)	16,764		sea
	Venice (Italy)	Vienna	601	19,089.0	land
Azerbaijan	Ulaanbaatar	Ulan-Ude	565		rail
	Ulan-Ude	Yekaterinburg	3,826		rail
	Yekaterinburg	Baku	1,992	6,383.0	land
Belarus	Ulaanbaatar	Brest, Belarus	7,200	7,200.0	rail
Belgium	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Ghent (BE GNE)	20,353	22,077.0	sea
Brazil	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Rio de Janeiro	21,207	22,931.0	sea
Bulgaria	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Burgas (BG BOJ)	16,050	17,774.0	sea
Canada	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Vancouver	9,582		sea
	Tianjin	Montreal	19,027	16,028.5	sea
Chile	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	San Antonio	19,492	21,216.0	sea
Colombia	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Buenaventura	16,548	18,272.0	sea
Czech Republic	Ulaanbaatar	Brest, Belarus	7,200		train
	Brest, Belarus	Warsaw	202		train/road
	Warsaw	Prague	619	8,021.0	train/road
Denmark	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Copenhagen (DK CPH)	21,354	23,078.0	sea
Estonia	Ulaanbaatar	Ulan-Ude	565		rail
	Ulan-Ude	Yekaterinburg	3,826		rail
	Yekaterinburg	Tallinn	2,101	6,492.0	land
Finland	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Helsinki (FI HEL)	22,300	24,024.0	sea
France	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Marseilles (FR MRS)	17,142	18,866.0	sea
Georgia	Ulaanbaatar	Ulan-Ude	565		rail
	Ulan-Ude	Yekaterinburg	3,826		rail
	Yekaterinburg	Tbilisi	2,028	6,419.0	land
Germany	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Hamburg	20,844	22,568.0	sea
Greece	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Athens	15,472	17,196.0	sea

Trading partner	Starting point	Point(s) en route and final destination	Distance between points en route (km)	Total distance (km)	Mode
Hong Kong	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Hong Kong (CN HOK)	2,508	4,232.0	sea
Hungary	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Venice (Italy)	16,764		sea
	Venice (Italy)	Budapest	702	19,190.0	train/road
India	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Mumbai	9,534	11,258.0	sea
Indonesia	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Jakarta	5,652	7,376.0	sea
Ireland	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Dublin	20,137	21,861.0	sea
Israel	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Tel-Aviv	14,600	16,324.0	sea
Italy	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Naples (IT NAP)	16,394	18,118.0	sea
Japan	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Japan	2,284	4,008.0	sea
Kazakhstan	Ulaanbaatar	Ulan-Ude	565		rail
	Ulan-Ude	Yekaterinburg	3,826		rail
	Yekaterinburg	Astana	825	5,216.0	rail
Korea (ROK)	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Seoul	840	2,564.0	sea
Kuwait	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Kuwait (KW KWI)	12,129	13,853.0	sea
Kyrgyzstan	Ulaanbaatar	Ulan-Ude	565		rail
	Ulan-Ude	Yekaterinburg	3,826		rail
	Yekaterinburg	Astana	825		rail
	Astana	Bishkek	1,116	6,332.0	rail
Latvia	Ulaanbaatar	Ulan-Ude	565		rail
	Ulan-Ude	Yekaterinburg	3,826		rail
	Yekaterinburg	Riga	2,199	6,590.0	land
Lithuania	Ulaanbaatar	Ulan-Ude	565		rail
	Ulan-Ude	Yekaterinburg	3,826		rail
	Yekaterinburg	Vilnius	2,202	6,593.0	land
Luxembourg	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Ghent	20,353		sea
	Ghent (BE GNE)	Luxembourg	279	22,356.0	rail/road
Malaysia	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Port Klang (MY PKL)	5,380	7,104.0	sea
Mexico	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Mazatlan (MX MZT)	12,740	14,464.0	sea
Netherlands	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Amsterdam (NL AMS)	20,472	22,196.0	sea
New Zealand	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Auckland (NZ AKL)	10,393	12,117.0	sea
Norway	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Bergen	21,255	22,979.0	sea

Trading partner	Starting point	Point(s) en route and final destination	Distance between points en route (km)	Total distance (km)	Mode
Philippines	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Manila	3,111	4,835.0	sea
Poland	Ulaanbaatar	Brest, Belarus	7,200		rail
	Brest, Belarus	Warsaw	202	7,402.0	train/road
Romania	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Constanta (RO CND)	16,190	17,914.0	sea
Saudi Arabia	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Dammam	11,834	13,558.0	sea
Singapore	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Singapore (SG SIN)	5,048	6,772.0	sea
Slovakia	Ulaanbaatar	Brest, Belarus	7,200		rail
	Brest, Belarus	Warsaw	202		train/road
	Warsaw	Bratislava	640	8,042.0	train/road
Slovenia	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Koper	16,724	18,448.0	sea
Spain	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Algeciras (ES ALG)	17,966	19,690.0	sea
Sri Lanka	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Colombo	7,921	9,645.0	sea
Sweden	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Gothenburg (SE GOT)	21,226	22,950.0	sea
Switzerland	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Venice (Italy)	16,764		sea
	Venice (Italy)	Bern	614	19,102.0	land
Thailand	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Bangkok (TH BKK)	5,062	6,786.0	sea
Tunisia	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Tunis (TN TUN)	16,533	18,257.0	sea
Turkey	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Istanbul	15,796	17,520.0	sea
Ukraine	Ulaanbaatar	Ulan-Ude	565		rail
	Ulan-Ude	Yekaterinburg	3,826		rail
	Yekaterinburg	Kiev	2,093	6,484.0	rail
United Arab Emirates	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Abu Dhabi	11,469	13,193.0	sea
United Kingdom	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Portland (GB PTL)	19,953	21,677.0	sea
United States	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	San Francisco	10,379		sea
	Tianjin	New York	19,967	16,897.0	sea
Vietnam	Ulaanbaatar	Tianjin	1,724		rail
	Tianjin	Ho Chi Minh City	4,150	5,874.0	sea

Distance calculation procedure:

- All distances are from Ulaanbaatar and sea distances are calculated from the port of Tianjin in China
- All distances are calculated to capital cities or the major ports closest to Ulaanbaatar suggested by data sources
- If rail connections are not clear, simple road distances from Google Earth are used
- If data on land distances are not available, approximation is used
- Distances to East European countries (those close to Russia) and Central Asian countries are calculated by rail via Russia
- Distances to the United States and Canada are averaged from the closest and furthest densely populated areas due to the large distances between the main ports
- In the case of Russia, distances are weighted via the cities on the Trans-Siberian Railway from Ulan-Ude to Moscow

Sources:

Distances between sea ports:

- http://www.portworld.com
- http://www.searates.com

Distances via rail:

- UNESCAP Project on "Operationalization of international intermodal transport corridors in North-East and Central Asia"
- http://train.spottingworld.com/Trans-Siberian_Railway
- Google Earth 5.0.11733.9347

Appendix 2: Correlation Matrix and Variance Inflation Factor Estimation of Explanatory Variables

a) Correlation Matrix

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1	log(GDP - Partners)	1.000												
2	log(GDP - Mongolia)	0.140	1.000											
3	log(GDP per Capita - Partners)	0.529	0.179	1.000										
4	log(GDP per Capita - Mongolia)	0.141	0.999	0.177	1.000									
5	log(FDI to Mongolia)	0.109	0.858	0.164	0.834	1.000								
6	log(Distance)	0.173	-0.011	0.493	-0.011	-0.008	1.000							
7	log(Trade/GDP ratio - Partners)	-0.501	0.157	0.055	0.151	0.186	-0.135	1.000						
8	log(Trade/GDP ratio - Mongolia)	0.028	0.287	0.069	0.242	0.632	-0.008	0.140	1.000					
9	log(Trade Freedom Index - Partners)	0.085	0.179	0.591	0.174	0.197	0.208	0.266	0.139	1.000				
10	log(Trade Freedom Index - Mongolia)	-0.004	0.149	0.048	0.113	0.421	0.002	0.101	0.713	0.102	1.000			
11	log(RER)	-0.158	-0.004	-0.510	-0.004	-0.011	-0.425	-0.007	-0.009	-0.231	-0.016	1.000		
12	WTO member - dummy	0.291	0.085	0.437	0.083	0.100	0.425	-0.065	0.068	0.251	0.024	-0.239	1.000	
13	Adjacency - dummy	0.190	0.000	-0.187	0.000	-0.008	-0.471	-0.129	-0.011	-0.298	-0.014	0.055	-0.322	1.000

b) Variance Inflation Factors

Variable	VIF	1/VIF	Variable	VIF	1/VIF
log(GDP - Mongolia)	10,791.59	0.0001	log(Distance)	2.09	0.4787
log(GDP per Capita - Mongolia)	9,839.57	0.0001	log(Trade/GDP ratio - Partners)	1.98	0.5063
log(FDI to Mongolia)	31.55	0.0317	log(Trade Freedom Index - Partners)	1.93	0.5189
log(Trade/GDP ratio - Mongolia)	9.79	0.1022	Adjacency - dummy	1.69	0.5921
log(GDP per Capita - Partners)	4.33	0.2309	log(RER)	1.56	0.6431
log(GDP - Partners)	3.09	0.3233	WTO member - dummy	1.43	0.6972
log(Trade Freedom Index - Mongolia)	2.32	0.4304	**Mean VIF**	**1,591.76**	

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