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Contents

Transport Infrastructure and Foreign Economic Cooperation of Mongolia

BATNASAN Namsrai*

Abstract

Transport infrastructure is one of the key issues of Mongolian foreign economic cooperation. This paper explores the nexus between transport infrastructure and country's trade performance, which will help contribute to our understanding of how the quality of internal transportation infrastructure affects regional access to international markets.

Keywords: freight demand, large mining projects, transport infrastructure and railway

1. Introduction

Transportation and logistics sector in our country is on the verge of major changes. In the recent few years, this sector encountered a number of challenging factor that affected its development and caused major changes in the economic structure, regional development, movement and settlement of the population. On the one hand, global economic crisis, the slowdown of Mongolia's economic growth and its major trading partners, the drop-in export prices, increasing foreign debt and financial difficulties are decreasing passenger and transport demand and deteriorating transport and logistics conditions. On a positive note, changes like expansion of economic cooperation between China and Russia and the development of major mining projects are boosting economic growth of the country, stimulating freight and passenger demand.

Correspondingly, it is necessary to update the transportation and logistics structure in harmony with the country's development focus. Before making large investments in the transportation and logistics sector, it is crucially important to develop and put in place an integrated sectoral development strategy that is in sync with the strategies of other sectors of the economy, as well as the development plans of large mining and industrial projects. Consequently, it is necessary to carryout well-found and comprehensive study in order to develop this sector.

Transportation and logistics sector of Mongolia, which consists of the railroad working at its full capacity, underdeveloped domestic road transport and air transport, which is offering scheduled passenger service only, obviously cannot meet the increasing demand of freight and passenger transportation.

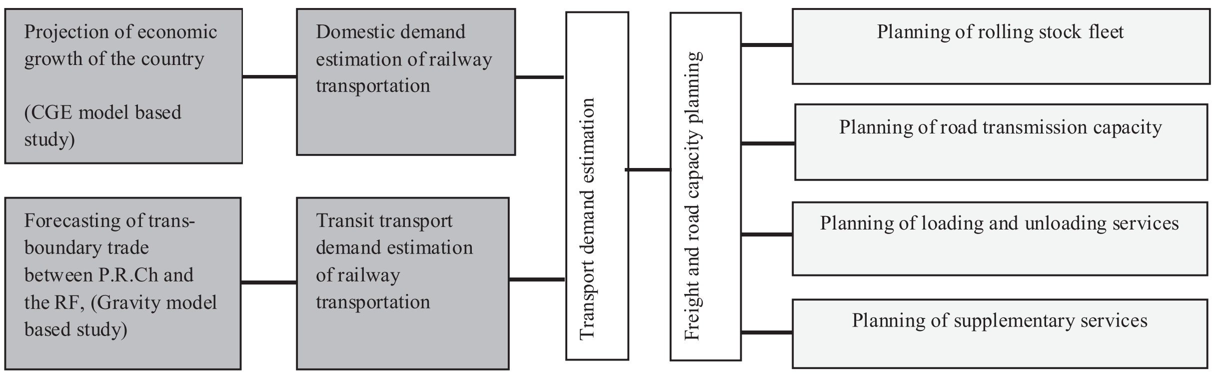
The outcome of any decision regarding economic policy could be measured by the socio-economic consequences after the implementation of the policy. The prerequisite for any successful implementation are fundamental research and study. Various studies have been done in regard to promoting the development of the transport and logistics infrastructure in Mongolia, including Pre-feasibility Study of New Railway Project, Mongolia (Ministry of Roads and Transportation of Mongolia, 2011), Strategic Plan of State-owned "Mongolian Railway" Company - 2020 (N. Batnasan, D. Narandalai, 2010), and Strategic Plan to Develop Air Transport Sector (N. Batnasan, 2008).

The study on the establishment of transport and logistics network needs to consider not only direct impacts from the development of large mining and industrial projects, but also the indirect impacts of those projects, including impact on freight turnover, population and work force movement and settlement, impacts from different sectors of the economy. On the other hand, resulting from the rapid changes in transportation and logistics environment, previous studies are now outdated and have become ambiguous in terms of factuality, hence the critical need to update some of the results of previous studies in conformity with the existing situation.

Within the framework of this study (Figure 1), we will take into consideration recent phenomenon of rapidly changing economic situation and confounding changes in economic structure that could affect to the transport demand. It also will consider the need for upgrading the supply side factors of the current transport and logistics infrastructure in meeting such demands. Furthermore, the study will cover main focus areas of the development of transport and logistics infrastructure in our country, the possibilities to integrate transportation and logistics policies with the foreign and macroeconomic policies of the country.

For those purposes of estimating the effect of factors affecting to the transport demand, such as country's GDP growth, trade expansion, intercorrelation and development of economic sectors, in the present study, author has used GDP growth forecast from the Dynamic General Equilibrium Model based study, which is being implemented in 2018[1]. And results of recent gravity model-based study implemented by researchers from Far Eastern Federal University of the Russian Federation was also used.

Figure 1. General Algorithm of Transport Demand Estimation, Freight and Road Capacity Planning



The following interrelated issues of transport and logistics infrastructure development have been researched within the framework of this study. They include:

- Transport demand for passenger and freight are dependent on economic situation and its changes. The assessment of direct and indirect impacts of mining sector on economy is based on the Dynamic Computable General Equilibrium Model (DCGE).
- Impact assessment of economic growth on transport demand is also based on the afore-mentioned DCGE model[2]. Furthermore, feasibility studies and investment estimations of large mining and industrial projects are reflected in the impact assessment.
- For the planning and calculation of railway rolling stock needed for railway transportation, we've used universal methodologies adopted from the Organization for Cooperation of Railways[3].

2. Analysis of current situation

Mongolia is a landlocked country, situated far from the world's major transport channels and sea ports, which mainly exports agricultural and mining products to world markets and provides its domestic consumption with import goods. For a country with high transportation cost alike Mongolia, railway transport has a significant role in the transport system of the country because of its advantages in terms of low transportation costs and contribution to trade and economic cooperation. Mongolia's railroad network, of which the north-to-south main line links with Naushki station on the Trans-Siberian railroad of the Russian Federation in the north and Erlian railway station in the PRC in the south, and it is approximately 1,908 kilometers in total length and accounts for over 80% of total freight ton-kilometers in the transport market. There is no east-west railway line crossing the country. This railway also serves as one of the important means of passenger transportation. The importance of the railway is magnified by the sparsely settled population, underdeveloped transport infrastructure, geography, the harsh continental climate, and great distance, which all make road connections inefficient.

The main line of the Mongolian railway is approaching to its full capacity; therefore, it is clear that the increase in transit transportation and exploitation of large mining projects would require additional capacity and investment. According to 2018 statistics, utilization rate of the main railway line capacity had reached to its full capacity and the railway transported a total of 25.6 million tons of freight[4]. Therefore, even a slight increase of freight transportation along the main railway line could surpass it's full operating capacity.

The main railway line is 1,110 kilometers long, which connects two border points of Sukhbaatar in the north and Zamyn-Uud in the south. The construction of 1 kilometers railroad costs about 2 million USD in the Mongolian context, hence the expansion of the main line capacity by constructing double railway track would still require at least 2.2 billion USD in investment[5].

In recent years, Ulaanbaatar railway has been trying to improve its capacity to carry freight from the current 25-27 million tons to 30 million tons a year[6] by constructing new railroad intersections, by increasing locomotive power and average speed of transportation, and by using railroad automatic switching systems. The increase of locomotive power would require that thickness of the layer of track ballast is increased from the current 20 centimeters to 35 centimeters.

The mandatory life span of locomotives and rolling stocks used at the Mongolian railway are 20-25 years old. According to guidelines, the percentage share of locomotives and wagons that have been used for more than 20 years should not exceed 20 % of the total locomotives and wagons and they have to undergo regular refurbishment. However, two thirds of the 2,792 freight wagons, more than one half of 340 passenger wagons, and three fourths of the 164 locomotives of the Ulaanbaatar Railway have been in service for over 20 years[7]. Moreover, there were several serious accidents in the last decades. Unfortunately, renovation overhauling of locomotives and increasing of the thickness of track ballast layer require large investment.

According to the strategic policies approved by the Mongolian Parliament, the Government of Mongolia is aiming to establish road and railway networks critically important for the country's economic development. The purpose of those policies is to increase the carrying capacities of the road and railway transportation, to build integrated and efficient transport network directed at meeting the rapidly growing transport demand, and further, utilize large mineral deposits, accelerate national economic development by way of exporting value added products, and to ensure long-term sustainable economic and social development.

The Government is planning to add an additional 5,600 kilometers, therefore, an unprecedented five-fold increase in Mongolia's railway system is underway. The addition of two more rail transit corridors – one for transit between Russia and China and the other enabling internal cargo to move to the two neighbors – will result in a total of three Mongolian transit rail corridors. The Government is planning to expand its railway network with the aim of using the mineral and oil resources in Mongolia's eastern and Gobi regions, and to improve the use of Dornod's dead-end railway, and furthermore ensure connection with to the transport routes of Northeast Asia. The strategic positioning of Mongolia's railway in relation to the Tavan Tolgoi and Oyu Tolgoi mines will increase its economic benefit and may change the country's economic and industrial landscape dramatically.

With the exploitation of the large mining projects, total railway freight transportation turnover is expected to increase dramatically. On the other hand, Mongolia's two neighbor with large economies are planning to expand their mutual economic cooperation, which means there could be a substantial increase in the transit freight transportation demand between them.

4. The impact of large mining projects on the economy

Rich reserves of coal, copper and other minerals are key revenue earners for Mongolia, however the fluctuation of the global commodities prices has a destabilising effect on the national economy. Due to falling prices for mineral products and raw materials on the global market, foreign direct investment in Mongolia becomes doubtful as can be illustrated by the fact that the double-digit economic growth between 2011 and 2013 shrank to as low as 2.3% in 2015, and even further to 1.2% in 2016. However, Mongolia's economy grew by 5.1% in 2017 and 6.9% in 2018, recovering strongly from the lowest level of the growth rate observed in the last two decades, that has been recorded in 2016.

In October 2009, the Government of Mongolia signed an investment agreement for the development of the Oyu Tolgoi copper mine and since has been searching for ways for an efficient development of coal production at the Tavan Tolgoi mine. It is clear that the exploitation of the giant Oyu Tolgoi copper mine with a reserve of 35.8 million tons of copper, 1.4 thousand tons of gold, and the 6.5 billion ton capacity Tavan Tolgoi coal mine would definitely make a weighty contribution to the economic growth of the country[8].

Those two mega projects of Oyu Tolgoi and Tavan Tolgoi are closely interrelated to each other. The exploitation of the Oyu Tolgoi mine would create the demand for the construction of a power plant using coal from Tavan Tolgoi, and finally surplus power could be exported. The construction of the thermal power plant would enable the country to set up an industrial complex producing end metallurgical products, including refined copper and steel.

Proceeding from this premise, it can be said that dependent on these two major projects are policies that are designed at cutting down on high transportation costs of export, exporting goods and products on the competitive markets, improving the efficiency of foreign trade, reducing dependency on external markets, expanding ties with industrialized countries, speeding up technological progress, promoting the development of industrial cluster based on relative advantage of the country, and accelerating the pace of the country's economic growth. Therefore, successful implementation of these projects will boost an economic capacity of not only the southern regions of the country, but also the overall national economy.

Accordingly, in order to determine the economic development prospects for Mongolia for the forthcoming years, this paper analyzes the development issues of transport and logistics system of the country, including the mining sector's direct and indirect impact by employing a dynamic Computable General Equilibrium (CGE) model[9]. This CGE based-study covers the impacts of two large investment projects, Oyu Tolgoi (OT) and Tavan Tolgoi (TT), to be expanded in the coming years. The Government of Mongolia is offering two different options of coal extraction at Tavan Tolgoi: 20 million tons (TT1) or 40 million tons (TT2) in a year. And Oyu Tolgoi company is aiming to expand its production capacity by more than doubling its current 850 thousand tons' copper concentration production in a year to 1,800 thousand tons.

Although Mongolia is a country with abundant natural resources, it has not reached such a level of industrialization that could otherwise transform raw materials from the mining sector into final products of metallurgical industry. Hence, the Government of Mongolia recently resolved to build a one-million ton capacity copper smelter (CR) at Oyu Tolgoi mine. According to preliminary feasibility study of this project, a total of 1.5-2.1 billion USD is required. The government is hoping that with the implementation of this project there will be a significant growth in GDP, budgetary and export revenues, job creation and establishment of different types of related factories.

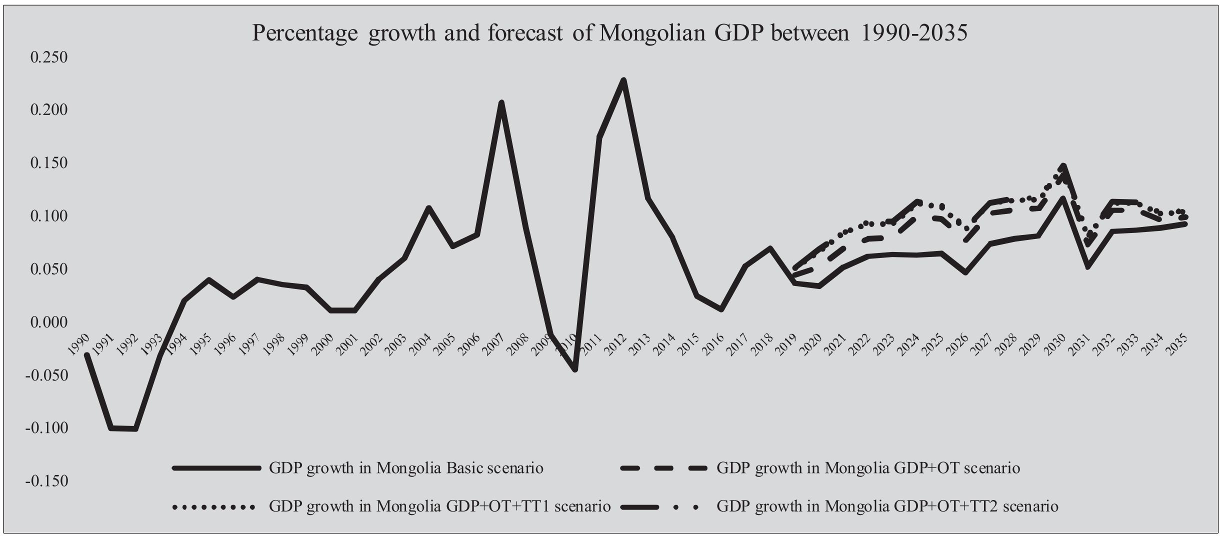
While considering the aforementioned situation of the economic development of Mongolia, four different scenarios in addition to the baseline scenario have been investigated in this study. They include the following:

1. Baseline scenario (BL)
2. Projection including OT expansion (BS+OT)
3. Projection including OT and TT1 expansion (BL+OT+TT1)
4. Projection including OT and TT2 expansion (BL+OT+TT2)

In all scenarios, we assumed that long term prices of metals would be at the level of current metal prices of 2.90 USD/pound for copper, 1,300.0 USD/oz for gold and 15.0 USD/oz for silver. We estimate that cumulative total investment in Oyu Tolgoi mine will 19.1 billion USD and initial investment before the start of the exploration would require an additional 5.1 billion USD as stipulated in the investment agreement signed with the government.

Furthermore, in the OT+TT1 scenario, we assumed that Tavan Tolgoi mine would extract and export 20 million tons of coal annually and the coal price will be 87 USD per ton as was the case in 2018[10]. The development of the coal mine will require 741.0 million USD in operating cost and tax rate estimated at 25.0% for income tax, 10.0% for VAT and royalty for natural resources at 5.0% respectively. In OT+TT2 scenario, we assumed that the annual extraction of coal from Tavan Tolgoi would be 40 million tons and the annual operating cost would be 983 million USD. Other conditions are similar to OT+TT1 scenario. These calculations were based on the "Integrated Development and Operations Plan" of Oyu Tolgoi project produced by the "AMC Consultants" Pty Ltd in 2012 and the balance sheet indicators of Tavan Tolgoi mine for the year 2016.

Figure 2. Percentage Growth and Forecast of Mongolian GDP between 1990-2035 under Different Scenarios



Source: BATNASAN Namsrai "Impact assessment of Mongolia – Korea EPA" MoFA, 2018

The economy will be affected directly and indirectly by the exploitation of the large mining projects. The GDP and trade volume will increase directly from the impact of such mining projects. According to 2018 statistics, average annual exchange rate was 2,472.4 tugriks for one USD and the GDP stood at 32.16 trillion tugriks. The GDP were divided by the total population, per capita GDP was 13,010.0 thousand tugrigks or 4,017.3 USD. Those are baseline indicators to be used for the further comparison of outcomes of our study.

The result of our study shows that if the large mining projects were not implemented and the current economic growth trend is maintained, the country's GDP will increase by 43.4% in 2025, 110.2% in 2030, and by 210.0% in 2035. GDP per capita is estimated as 5,280.8 USD in 2025, 7,233.5 USD in 2030 and 9,998.0 USD in 2035, with a 1.3% increase in a year, similar to the average population growth rate in the last decade.

If the Oyu Tolgoi mine development and production are maintained according to its planned schedule and if the Tavan Tolgoi annual coal output is brought up to 20 million tons, then the GDP can increase by 49.8% in 2025, by 115.9% in 2030, and 211.9% in 2030 from the current level and GDP per capita is estimated to be 5,498.8 USD in 2025, 7,429.8 USD in 2030 and 10,115.9 USD in 2035 respectively. If Tavan Tolgoi's annual coal production reached 40 million tons then it is estimated that GDP per capita would be 5,507.7 USD in 2025, 7,437.8 USD in 2030 and 10,115.9 USD in 2035 at the current price level. Simulation results indicate that the development of the giant mining projects will significantly increase growth and size of Mongolia's economy (Figure 2).

Our calculation shows that exploitation of large mining projects would lead to an increase in mining and business services sector's share in GDP, while there would be a decline in the rest of the sectors of the economy. The mining industry accounted for 23.6% of Mongolian GDP value in 2018, considering the effects of global commodity prices and the implementation rates of the projects, the ratio is estimated to be 16.7-17.0% by 2035.

Table 1 shows the future freight demand of the main railway line. The first column in the table shows the condition where large mining projects are inactive. The third and fourth columns show the increase in the demand for railway, including freights generated by Oyu Tolgoi and Tavan Tolgoi, when coal production would be 20 and 40 million tons respectively.

Table 1. Forecast of Freight Demand for the Main Railway Line

Year	Freight demand / mln.ton				
	Domestic	Export	Import	Transit	Sum
Forecast of freight demand under BL scenario					
2018	10,326.8	9,272.4	2,798.4	3,365.7	25,763.3
2025	13,052.8	18,541.3	4,030.3	1,739.0	37,363.5
2030	16,363.1	27,430.5	5,827.0	3,667.6	53,288.3
2035	21,759.6	41,823.7	8,593.2	5,395.3	77,571.8
Freight demand under BL+OT scenario					
2025	13,245.6	18,647.8	4,149.9	1,739.0	37,782.3
2030	16,624.9	27,998.6	5,949.2	3,667.6	54,240.3
2035	21,961.8	42,806.2	8,654.3	5,395.3	78,817.6
Freight demand under BL+OT+TT1 scenario					
2025	13,329.6	18,770.9	4,192.2	1,739.0	38,031.7
2030	16,718.1	28,259.9	5,990.2	3,667.6	54,635.8
2035	22,060.3	43,175.5	8,697.4	5,395.3	79,328.5
Freight demand under BL+OT+TT2 scenario					
2025	13,342.2	18,785.5	4,198.9	1,739.0	38,065.6
2030	16,731.5	28,292.4	5,996.7	3,667.6	54,688.2
2035	22,076.1	43,227.4	8,704.5	5,395.3	79,403.3

Source: author's estimate

Under the indirect impact of the large mining projects, the GDP and total consumption tend to increase which make it imperative to increase freight demand. Using the feasibility studies of large mining projects and GDP calculation from our previous study, based on DCGE model, we have estimated the freight demand of forthcoming years by using the error correction model (Table 2).

Table 2. Error Correction Model

Freight demand is taken as Y and GDP as X. If they have linear correlation $y=\beta_0+\beta_1 x$, difference between actual and estimated values then they would have an error margin of $ut= y - \beta 1x$.
Error correction model's main equation has the following features: $\Delta y_t = \alpha_1+\alpha_2 u_{t-1}+\alpha_3\Delta x_t+\alpha_4 x_{t-1}+\alpha_5 y_{t-1}+\nu_t$ $\Delta x_t = x_t - x_{t-1}$ $\Delta y_t = y_t - y_{t-1}$
x_t – GDP of t-the year y_t – domestic freight demand for the year - t

After testing the impact of factors that could influence the freight demand, we have investigated that the most influential factor is GDP growth. By using above mentioned estimation of GDP, we were able to forecast the freight demand up to the year 2035.

However, it is possible to estimate domestic freight demand based on our dynamic CGE model study, demand estimation of transit freight requires the forecasting of trans-boundary trade between China and the Russian Federation, using gravity model. For this purpose, I've used the result of recent study implemented by researchers from Far Eastern Federal University of the Russian Federation[11]. The result of this study is reflected in Table 3.

Table 3: Bilateral Trade between China and Russia

Model	Variable	Value (t-statistics)	Equation of dependence	Coefficient of determination R^2 / (F-value)
Export flow	α_0 α_1 α_2	3.444 (2.74) ** 0.289 (2.60) ** 0.763 (7.81) ***	$E = \alpha_0 Y_1^{\alpha 1} Y_2^{\alpha 2}$ (1) $E=3.444Y_1^{0.289}Y_2^{0.763}$	0.96 (237.77)*
E: total export, Y_1: per capita GDP in Russia, Y_2: per capita GDP in China, α_0: regression parameter, α_1: elasticity of export (the exporter-country's GDP), α_2: elasticity of export (the importer-country's GDP)				
Import flow	α_0 α_1 α_2	0.018 (6.28) *** 0.908 (5.75) *** 0.715 (5.155) ***	$I= \alpha_0 Y_1^{\alpha 1} Y_2^{\alpha 2}$ (2) $I=0.018Y_1^{0.908}Y_2^{0.715}$	0.96 (256.70)**
I: total import, Y_1: per capita GDP in Russia, Y_2: per capita GDP in China, α_0: regression parameter, α_1: elasticity of import (the importer-country's GDP), α_2: elasticity of export (the exporter-country's GDP)				
With dummy variable included	α_0 α_1 α_2 γ_1 γ_2	2.706 (2.45) ** 0.546 (6.87) *** 0.537 (6.44) *** Inclusion of variable is statistically irrelevant 0.447 (4.82) ***	$T=\alpha_0 Y_1^{\alpha 1} Y_2^{\alpha 2} e^{\gamma 1 D1}\, e^{\gamma 2 D2}$ (3) $T=2.706Y_1^{0.546}Y_2^{0.537}e^{0.447D2}$	0.99 (449.45)**
T: total trade turnover, Y_1: per capita GDP in Russia, Y_2: per capita GDP in China, α_0: regression parameter, α_1, α_2: elasticities of trade turnover of Russia and China, respectively Dummy variables D_1 for Russia and D_2 for China, which equal to 1 if a country is a member of WTO, and γ_1 and γ_2 are respective coefficients of variables				

**Significant at 5%, ***Significant at 1%.
Source: Evgenie P. Zharikov, Alla A. Kravchenko, Olesya O. Sergeeva, Victor V. Stetsyuk (2016)

The final result of Gravity model-based estimation of bilateral trade between China and the Russian Federation has given us an opportunity to forecast transit freight demand of the main railway line. We assumed here that, particular share of export and import goods to be traded between China and Russia should transported through Mongolian territory. For this purpose we've calculated weighted average of percentage share. Table 3 shows domestic, export, import and transit freight demand forecasting.

Transportation of freight as stated requires the expansion of the existing capacity of the main railway line and emphasizes the need for a double parallel railway line. Besides this, increasing freight demand will require additional number of locomotives and wagons. Table 4 shows the number of locomotives and wagons required for the above stated freight transport after the exploitation of large mining projects. This would require an estimated investment of 0.8-1.4 billion USD.

Table 4. Number of Locomotives and Wagons Needed for Transportation in Main Line

	2025				2030				2035			
	BL	BL+OT	BL+OT+TT1	BL+OT+TT2	BL	BL+OT	BL+OT+TT1	BL+OT+TT2	BL	BL+OT	BL+OT+TT1	BL+OT+TT2
Locomotive	229	230	230	231	313	314	318	318	455	457	462	463
Wagon	16,649	16,735	16,783	16,836	22,209	22,209	22,318	22,555	32,330	32,414	32,824	32,849

Source: author's estimate

Even though it is important to increase the quantity and speed of freight transportation by expanding the main line, this kind of expansion will not be able to connect products of mining sector to its main markets. Moreover, these mining deposits could not be connected to major cities and industrial centers such as Erdenet, Darkhan, and Sainshand, where the government has been planning to build large industrial complexes. In other words, there won't be any change in the status of current unprocessed raw material export, and what's more, the plan to build industrial complexes could fall apart simply because of the non-availability of any raw material supplies to these centers.

Currently, the government has given the right to build the railway lines in the southern region to a state-owned company "Mongolian Railway" LLC and has granted the right to a private sector enterprise to build railroads from Tavan Tolgoi through Oyu Tolgoi to the state border.

There are four main alternatives to connect OyuTolgoi and Tavan Tolgoi to international market. First, building 126 kilometers long railway line from Tavan Tolgoi to Oyu Tolgoi and another 80 kilometers railroad from Oyu Tolgoi to state border, which would facilitate the export of copper concentrates and coals from these mines directly to the Chinese market. Second, connecting these mine deposits to the main railway line by building 126 kilometers long railroad from Oyu Tolgoi to Tavan Tolgoi and another 496 kilometers long railway line from Tavan Tolgoi to Zuunbayan. Third, building 725 kilometers railway line connecting Zuunbayan to Tavan Tolgoi including Oyu Tolgoi and Gashuun Sukhait. Fourth, extending the third alternative by connecting it to the Sainshand-Choibalsan line. These alternatives, which are designed at facilitating transportation of raw materials from large mining deposits, have their own advantages, as well as disadvantages.

For instance, the first option would make it possible to market raw materials at the lowest possible investment cost. If the railway line would be of narrow gauge, then the products will be supplied to the market without trans-shipment that would lower the cost altogether. This alternative gives the opportunity to connect large deposits to Chinese market at a low investment cost, however, without linking these deposits to the main railway line, it will be unrealistic to process these minerals domestically, what's more, other foreign markets will remain closed.

In case of the second alternative, this would require a heavy investment, and products will be supplied to the market after longer transportation routes featuring trans-shipment. Moreover, there will be loading and unloading at the main railway line which would make it important for building a double railway line for the Sainshand-Zamyn Uud line in order to increase the existing transport capacity. It is extremely important to build new railway lines that connects Oyu Tolgoi and Tavan Tolgoi mines to the main railway line in order to connect these strategically-important deposits to the planned domestic manufacturing factories and to export minerals from these deposits to markets in Russia, Europe, Japan and Korea at a competitive price.

If the third alternative is chosen, it will present the opportunity to implement both first and second options separately or both of them combined together at the same time. If the new railway lines would be exploited exactly as outlined in the first and second alternatives, there will be some deficiencies that would arise. The main weakness of this alternative from an economic standpoint would be the low efficiency of the route connecting the deposits to the main railway line.

For the fourth alternative, even though it requires higher investment, this route has some advantages such as exporting extracted minerals to Southeast Asian markets through Russia, linking the eastern region of the country with the rest of Mongolia. Strategic eastward expansion into the ports of Vladivostok, Vostochny and Vanino in the Far East of the Russian Federation will introduce new points of access into the key potential markets such as Japan, Korea and Southeast Asia. What's more, route could facilitate in developing domestic oil refinery relying on the oil deposits of Dornod aimag in the extreme west of the country. Here transportation costs could be higher considering the distance between Sainshand, Ereentsav and Vladivostok, when going around the northern frontier of China through the Russian territory. However, transportation cost could be reduced significantly thanks to the preferential condition granted by the Russian Federation. Thus, the second, third and fourth alternatives, which connect Oyu Tolgoi and Tavan Tolgoi deposits to the main railway line look promising.

Many different ideas are floating on the matter whether state or private owned entities should build and operate the new railway lines or not. Once the government begins the construction of the new railway lines, private companies in the mining industry will join the railway-building network and it will increase the chance to build a new additional line. Mongolia's Ministry of Road and Transportation is prepared to support private investment and it has to date received a number of unofficial proposals. The ministry has also given the license to build the railway lines connecting Tavan Tolgoi, OyuTolgoi and Gashuun Sukhait.

4. Conclusion and recommendations

In the present conditions of high transportation costs, Mongolia does not have the possibility of supplying, at a relatively higher price, such commodities as thermal and coking coal, copper concentrate and iron ore, to markets that can offer comparatively higher prices. For Mongolia, it has become inevitable to use minerals deposits as economic leverage, increase the economic benefit by developing mining-based manufactures, expand foreign economic cooperation with its major trading partners, and start successful beginnings to suit the long-term development of the country.

Mongolia is inherited railway infrastructure from the past, that is not ideally suited to country's future economic development needs. The development of mining-based cluster will make it incumbent to focus attention on developing production and transport infrastructures. The volume of goods transported by railway is likely to grow drastically with the development of the major extractive industries. However, today it has become obvious that the existing railway capacity would be unable to meet the challenges of such a growing demand, and therefore, there would be an imperative need to lay new railway lines. To attain these goals, it is truly important to develop mining-based infrastructure and to choose the most optimal alternative.

According to our study, firstly, the third alternative, which allows mineral deposits to be connected to the both the neighboring markets and the main railway line, must be opted for; secondly, go for the government proposal, submitted to the Parliament, in which export costs can be reduced by not requiring trans-shipment; and thirdly, we recommend that the steps to shift from the third to the fourth alternative should be taken early in the near future.

And there are considerable expenditure needs to invest required construction of new railway lines and to upgrade existing route. The construction of 1 kilometer railroad costs about 2 million USD in the Mongolian context, hence the construction of the different alternatives of new railway lines would require between 0.5 to 3.8 billion USD in investment.

The combination of country's economic growth, growth resulting from the investment in large mining projects will require a major change in the size and composition of the rolling stock fleet over the next two decades. With the assumptions and scenarios modelled in this article, the total number of wagon is forecast to grow by between 11.6 and 11.8 times by 2035, while the number of locomotives would rise from 2.78 today to more than 2.82 times over the same period. Rolling stock fleet innovation under different scenarios would require extra 3.4-3.5 billion USD investment at the current level of price wagons and locomotives.

Economic development and the transport infrastructure are closely related, and in fact it is impossible to industrialize and boost economic growth in Mongolia without the construction of new railway lines.

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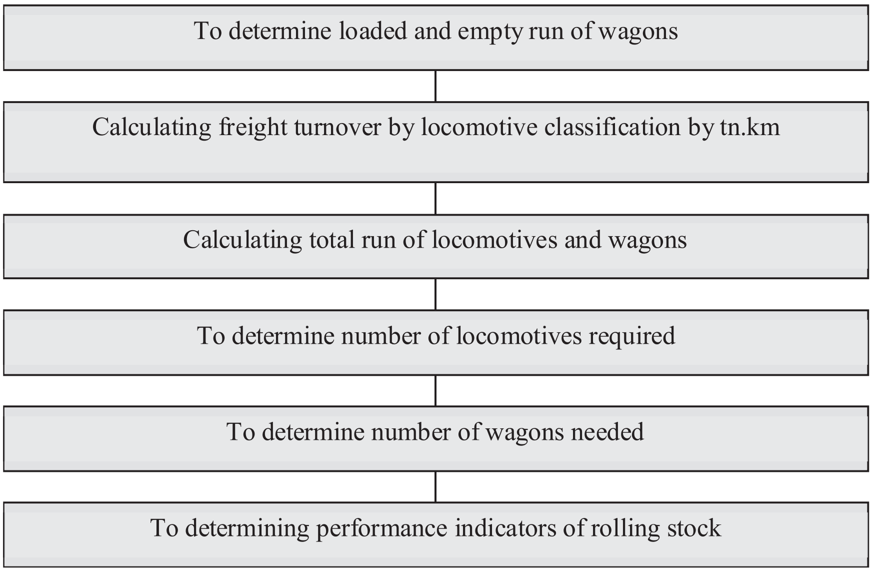
APPENDIX

Calculation methodology

The calculation of number of locomotives and wagons has been made in accordance with universal methodologies adopted from The Agreement on International Goods Transport by Rail (SMGS). General algorithm of calculation is shown below.



Calculating number of locomotives required per day:

$$N_{loc} = \frac{\Gamma_t \text{ x } K_{un}}{365 \text{ x } Q_{br} \text{ x } \varphi}$$

Nloc – number of locomotives required per day
Γt – total weight of freight at t-th year, tns
Kun – unbalance degree coefficient of freight transportation
Qbr – gross weight of the locomotive
φ - ratio of net and gross weights of the locomotive

Calculating number of wagons in a train:

$$N_{wag} = \frac{Q_{net} \text{ x } \varphi}{Q_{st}}$$

Nwag –Number of wagons in a train
Qbr – Gross weight of the locomotive
Qst – static tonnage of the wagon
φ - ratio of net and gross weights of the locomotive

Calculating the total number of wagons in operation:

$$n_{\text{p}} = \frac{1}{24}\left[\frac{\Sigma ns}{v_r} + \Sigma n_k t_k + \Sigma n_t t_t\right]$$

np – Number of operating wagons
Σns – Distance run by the wagon, wagon.km
νr – Average speed of locomotiveon the route, km/hour
Σnktk – Wagon hours for loading and unloading
Σnttt – Wagon hours for maintenance

Calculating total wagon number:

$$n_{инв} = n_p \times (1 + \beta)$$

пинв – Total number of wagon
np – Number of wagons in operation
β - a coefficient to determine the number of wagons out of operation

Growth and Inflation Regimes in Greater Tumen Initiative Area

ERDENEBAT Bataa*

Abstract

This paper tests for multiple structural breaks in the mean, seasonality, dynamics and conditional volatility of Greater Tumen Initiative Countries' (GTI) growth and inflation, while also accounting for outliers. It finds a drop in the level of Chinese growth rate in the third quarter of 2011 and of inflation rate in 1998. There are more volatility regimes than the growth regimes and most GTI countries are currently enjoying historically low volatility of their growth and inflation. Two exceptions are the increased growth volatility for Japan since 2006 and inflation volatility for Russia since 2012. There is an increased importance of seasonality in GTI and especially in Chinese inflation volatility, constituting at least a half of the total volatility.

Keywords: China slowdown, multiple structural breaks, seasonality, Greater Tumen Initiative, growth and volatility regimes, growth and inflation.

JEL classifications: E31, E32, C22, C18

1. Introduction

China, Mongolia, Russia and South Korea have agreed to transform the Greater Tumen Initiative (GTI) into an international organization of economic cooperation in Northeast Asia during the summit in Yanji, China on September. 17, 2014[1]. The Tumen River Area Development Programme (TRADP) was first formed by the United Nations Development Programme (UNDP) with the objectives of regional cooperation, economic development, and environmental management in 1995. In spite of its great potential GTI had been largely inactive due to several challenges, including disharmony of interest among member countries, weak infrastructure development, and lack of funding to activate the project. However, GTI has received new stimulus since China adopted it as part of its central economic development plan in 2009. This paper sheds light on the recent developments in the main macroeconomic variables of growth and inflation for these four countries and Japan, currently an observer nation to the initiative.

There are many earlier studies on growth and inflation regimes but none fully focuses on this important geographical region that produces about a quarter of the World GDP[2]. The moderation in volatility of output has been well documented for the US and other developed countries, see McConnell and Perez-Quiros (2000), and Gadea, Gomez-Loscos and Perez-Quiros (2018), among others. Coric (2012) studies 98 countries and finds that almost two thirds experienced GDP growth volatility decline between 1961 and 2007, implying that the so-called "Great Moderation" took place in economies at all income levels.

On the other hand, Easterly, Kremer, Pritchett and Summers (1993) find that medium term growth lacked persistence, and countries transitioned between high and low growth regimes. Ben-David and Papell (1998), Pritchett (2000), Hausmann, Pritchett and Rodrick (2005), Jones and Olken (2008), Berg, Ostry, Zettelmeyer (2012) show that the growth regimes are indeed more important phenomena than the long run average growth rate that masks them. Yet Kar, Pritchett, Raihan and Sen (2013) criticize that the structural break tests that are used to identify the growth regimes suffer from low power, due to the presence of high volatility in shorter annual samples, hence miss some of the "true" regimes.

Kar et al. (2013) suggest to refrain from using purely statistical test but to marry it with an ad hoc filter approach that has been used in earlier studies of Hausmann et al. (2005), and Aizenman and Spiegel (2010), among others. In particular, they propose evaluating the sample splits derived from Bai and Perron's (1998, 2003) dynamic programming approach based on a priori defined filters and find more breaks. In contrast to the earlier works that often use a simple model with regime dependent intercept (e.g. Jones and Olken, 2008), Jerzmanowski (2006) and Kerekes (2012) use Markov-switching AR(1) model for the growth rates, whose intercept, AR coefficient and volatility depend on four different regimes: growth, stagnation, crisis and miracle growth. But the condition that the intercept, AR coefficient and volatility are required to change at the same time can be restrictive.

Although the Great moderation and growth regime literatures both address the economic development, which makes "hard to think about anything else" (Lucas, 1988) due to its implication for human well-being, the former often uses the growth rates of quarterly real GDP while the latter relies on that of the annual real GDP per capita. Therefore, the first contribution of the paper is to use the recently developed iterative structural break testing methodology of Bataa, Osborn, Sensier and Dijk (2014) and to identify growth regimes in the GTI using the longest and most up-to-date quarterly data, to increase power of the test.

Blanchard and Simon (2001) show that while the causes of the decline in US output volatility are complex, this decline can be linked to changes in the properties of inflation and particularly to a decline in inflation volatility over the period 1952-2001. Similarly, Eichengreen, Park and Shin (2012) find that policy instability, measured by high and variable inflation rates, are precursors to growth slowdowns. Therefore, my second contribution is to search for coincident changes in inflation and growth properties. This is in line with Jones and Olken (2008) who ask what the breaks actually entail without making statements about the direction of causality between the variables.

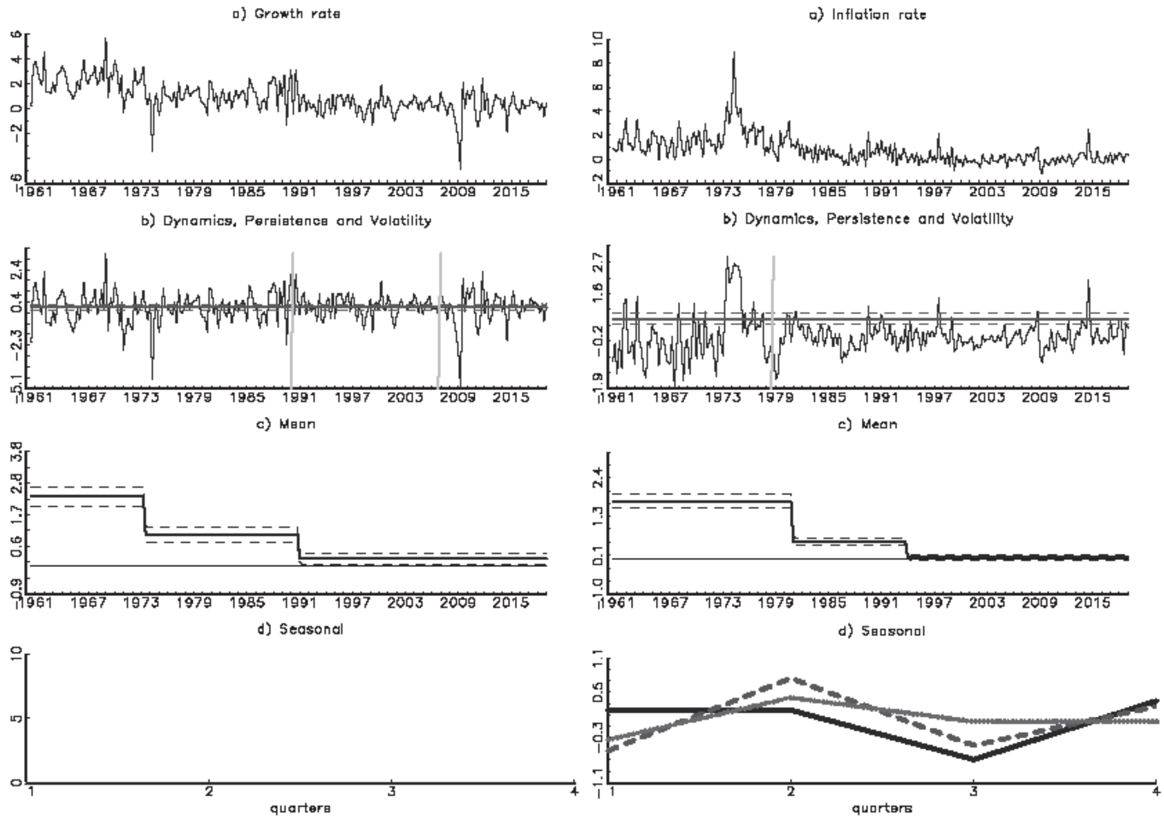
The paper is organized as follows. Section 2 explains the data and summarizes the iterative decomposition method of Bataa et al. (2014) to identify and distinguish between breaks in mean, seasonality (if any), persistence and (conditional) volatility of the growth and inflation series, while also accounting for the possible presence of outliers. Section 3 provides the results and compares with previous studies. Section 4 concludes.

2. Data and Methodology

I analyse quarterly real GDP growth and CPI inflation rates for each of the GTI countries. The sample for China, Russia and Mongolia starts later than the other two countries due to the lack of quality data. The start dates are therefore the second quarters of 1960 for Japan and South Korea, of 1993 for China and of 1995 for Mongolia and Russia. All end in the last quarter of 2018[3]. Russian and Mongolian growth rates and all the inflation rates are not seasonally adjusted.

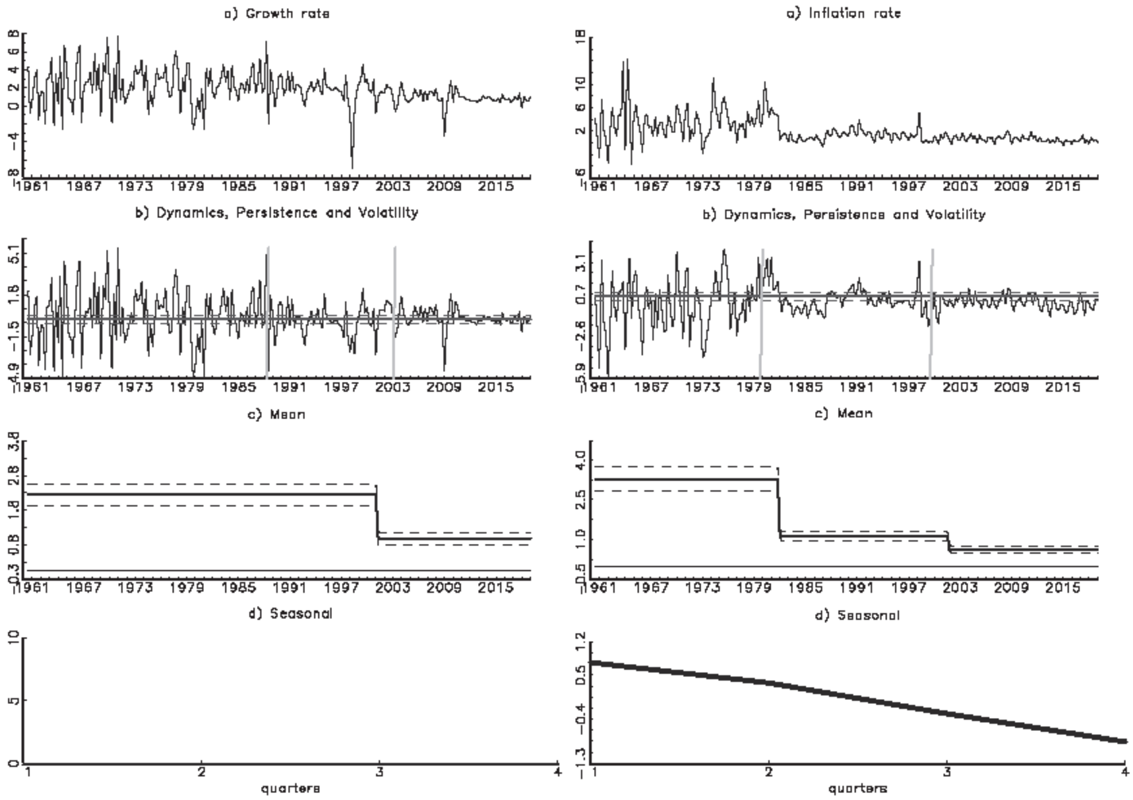
Panel a) in each of Figures 1 to 5 show the raw series analysed. One can easily eyeball the presence of outliers (see, for example, Japanese inflation after the first oil shock in Figure 1), changes in mean inflation (such as for Russia, Figure 4) and/or volatility (apparently present for Chinese, and South Korean growth and Mongolian inflation, Figures 3, 2 and 5). Seasonality is also evident in many of the series, with this perhaps being clearest for Russian and Mongolian growth as the peaks and troughs occur with 12-month intervals (Figures 4 and 5, respectively).

Figure 1: Japan Decomposition



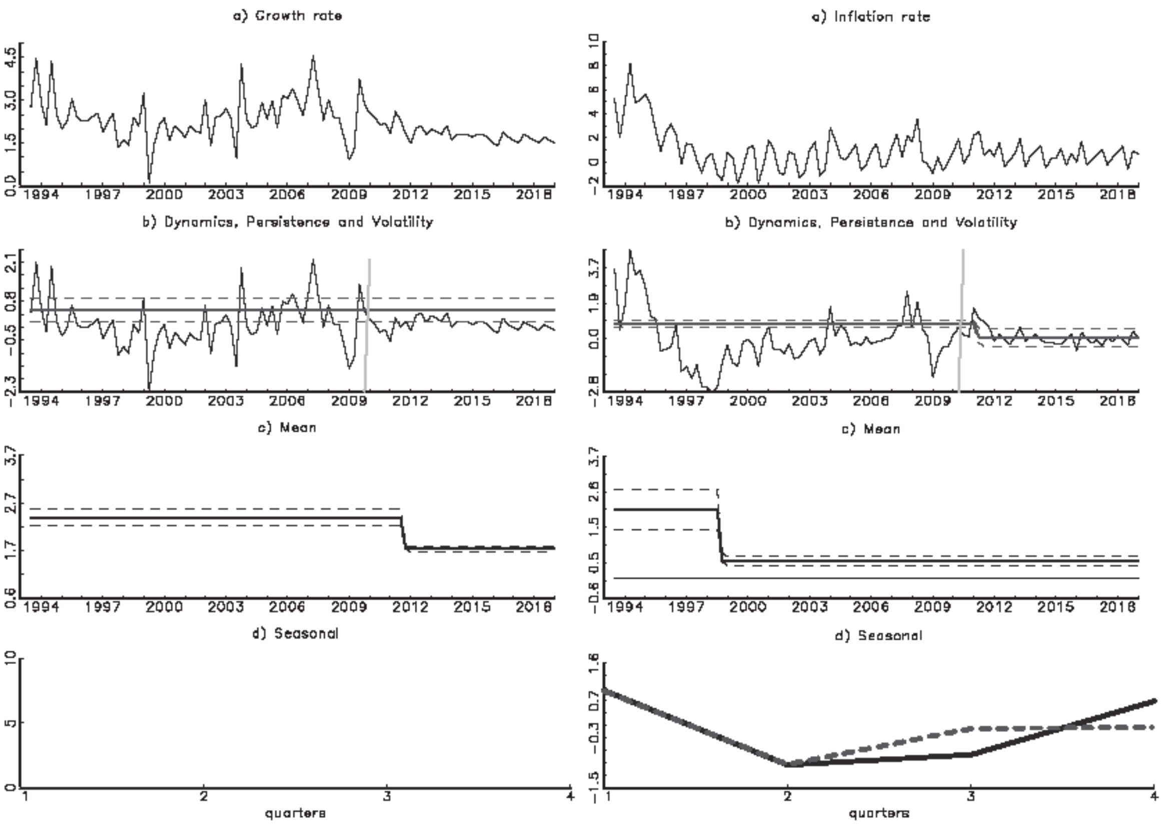
Notes: Panels show: a) observed growth and inflation, b) dynamic component, persistence (straight line) and volatility break dates (vertical lines); c) regime means and d) deterministic seasonal component for regime 1 in solid, regime 2 in dashed and regime 3 in dotted lines respectively.

Figure 2: South Korea Decomposition



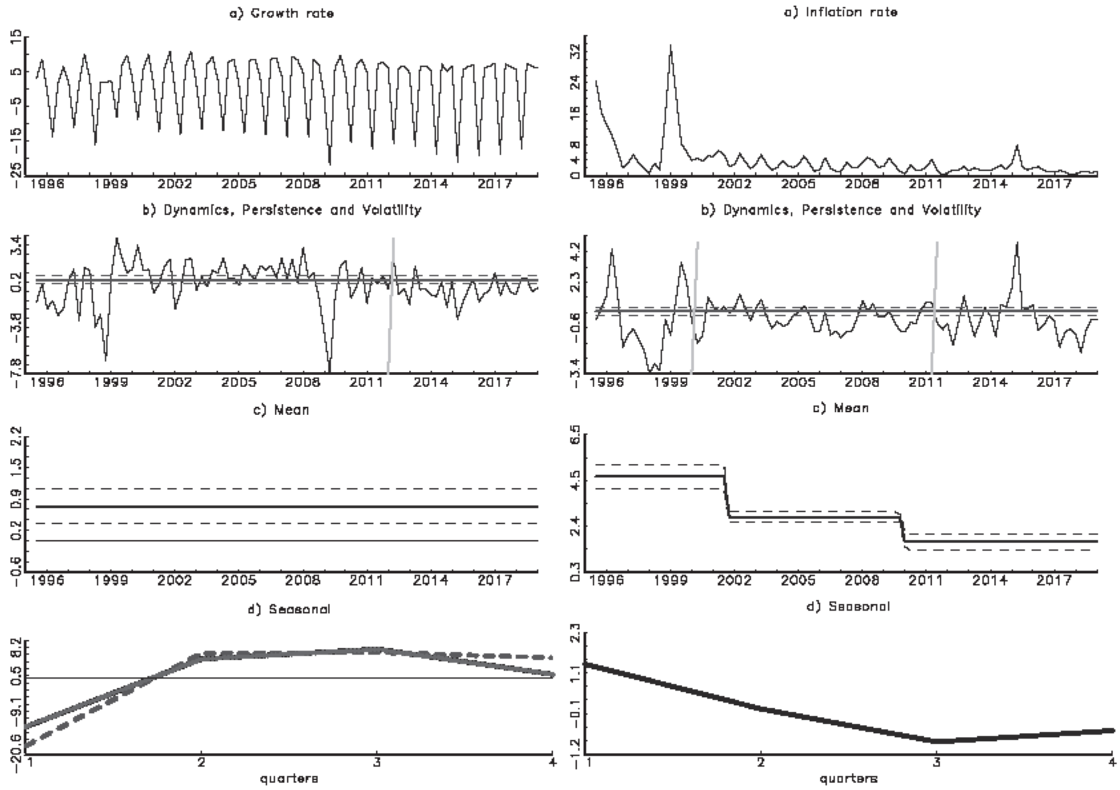
Notes: See Figure 1.

Figure 3: China Decomposition



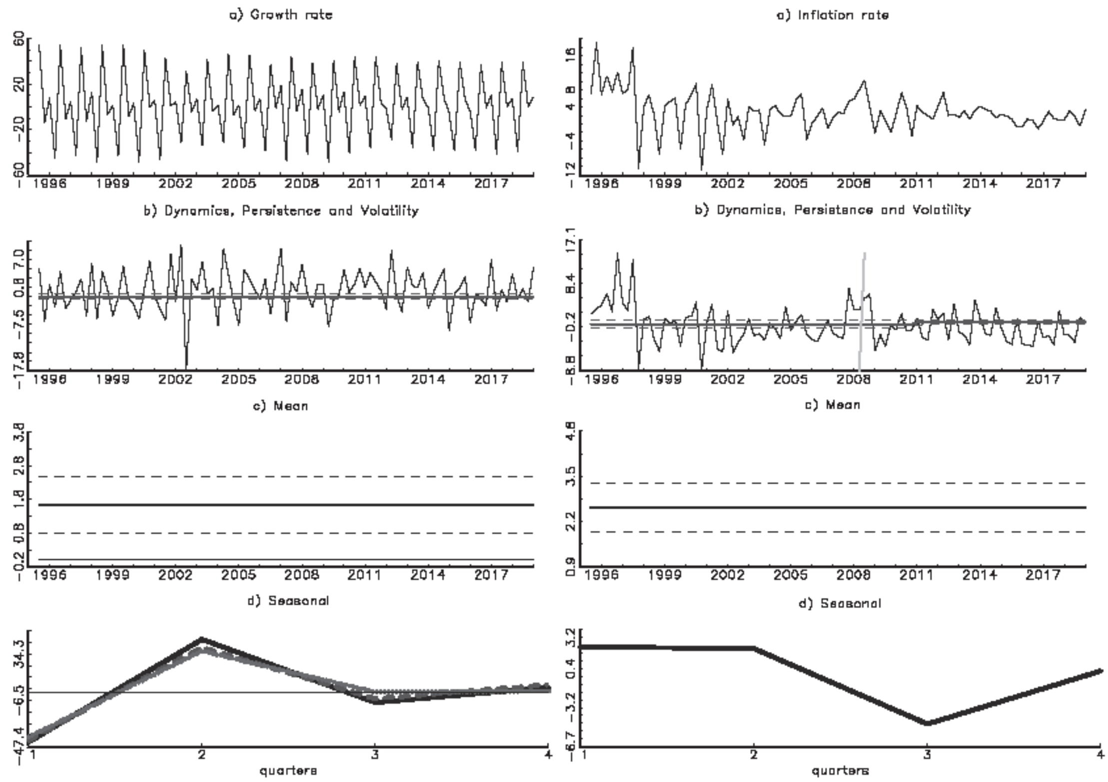
Notes: See Figure 1.

Figure 4: Russia Decomposition



Notes: See Figure 1.

Figure 5: Mongolia Decomposition



Notes: See Figure 1.

Bataa et al. (2014) consider decomposing a stationary time series Y_t into components capturing level (L_t), seasonality (S_t), outliers (O_t) and dynamics (y_t), where level and seasonality are deterministic and only the last component is stochastic and represented by means of an autoregressive (AR) process (although this could include stationary stochastic seasonality, if appropriate).

The model they consider allows for structural change in each of the level, seasonal and dynamic components, where breaks in the latter may occur in the AR coefficients or in the conditional volatility. A crucial feature of the model is that the numbers of structural breaks in these components do not have to be the same and nor do their temporal locations, hence might prove more flexible than the Markov-switching framework used in Jerzmanowski (2006) and Kerekes (2012). The general model specification is given by

$$Y_t = L_t + S_t + O_t + y_t \tag{1}$$

$$L_t = \mu_{k_1} \qquad t = T^1_{k_1-1}+1,\dots,T^1_{k_1}, \quad k_1 = 1,\dots,m_1+1 \tag{2}$$

$$S_t = \sum_{l=1}^{s} \delta_{k_2 l} D_{lt} \qquad t = T^2_{k_2-1}+1,\dots,T^2_{k_2}; \quad k_2 = 1,\dots,m_2+1 \tag{3}$$

$$y_t = \sum_{i=1}^{p} \phi_{k_3,i} y_{t-i} + u_t \qquad t = T^3_{k_3-1}+1,\dots,T^3_{k_3}; \quad k_3 = 1,\dots,m_3+1 \tag{4}$$

$$\sigma^2_{u,t} = var(u_t) \qquad t = T^4_{k_4-1}+1,\dots,T^4_{k_4} \;; \quad k_4 = 1,\dots,m_4+1 \tag{5}$$

where m_j denotes the number of breaks of type j that occur at observations $T^j_{k_j}$ (k_j = 1, ..., m_j), with $T^j_0 = 0$ and $T^j_{m_j} = T$ (where T denotes the total sample size), and for s seasons per year (s = 4 for quarterly data), D_{lt} (l = 1, …, s) are seasonal dummies equal to unity if the observation at time t falls in season l and zero otherwise. Note that the coefficient $\delta_{k_2 l}$ represents the deviation of the unconditional mean of Y_t in the l-th season (month) from the overall mean level μ_j and, for identification purposes, we impose the restriction $\sum_{l=1}^{s} \delta_{k_2 l} = 0$ for all seasonality regimes k_2 = 1, …, m_2+1.

I can then define the seasonal share in the total volatility as in (6), where $\sigma^2_{S,t}$ and $\sigma^2_{y_t}$ are simply standard deviations of the fitted values of (2) and (4) respectively:

$$Ss_{k_5} = \frac{\sigma^2_{S_t}}{\sigma^2_{S_t}+\sigma^2_{y_t}} \qquad t = T^5_{k_5-1}+1,\dots,T^5_{k_5}; \quad k_5 = 1,\dots,m_2+m_3+m_4+1 \tag{6}$$

Although our principal interest is the possibility of breaks in the components (2) to (5), outliers are corrected to prevent these distorting inferences concerning other components. Outliers, O_t in (1), are observations that are abnormally distant from the overall level, defined as 5 times interquartile range from the median and, when detected, are replaced with the median of the six neighbouring non-outlier observation. The null hypothesis of no break is tested against an unknown number of breaks up to M using WDMax test and if rejected the exact number of breaks are identified using sequential tests Seq(i+1|i), starting with i=1 as in Bai and Perron (1998, 2003). Bataa et al. (2014) employ an iterative approach using Qu and Perron (2007) test to examine breaks in each of the components of (2)-(5) and the details of their methodology are relegated to the original study to conserve space.

There is a well-known trade-off between size and power when choosing the maximum number of breaks (M) and trimming parameter, that is the minimum fraction of the sample between any two breaks (see Bai and Perron, 1998, 2003). My choice is to allow for a maximum of three breaks (20% trimming) except for the autoregressive and seasonal parameters for China, Russia and Mongolia. For these I consider up to two breaks (30% trimming). The results are quite robust to other sensible parameterization.

3. Empirical Results

Figures 1 to 5 show the empirical results of the iterative decomposition in graphical form. These charts provide: a) the original unadjusted GDP growth and CPI inflation series; b) the estimated dynamic component y_t (constructed by removing outliers, mean and seasonal components) together with its estimated persistence, defined as the sum of the autoregressive coefficients in (4) and corresponding ± 2 standard error bands (in dashed lines), and volatility break dates (vertical lines); c) the level component L_t with ± 2 standard error bands; and d) the estimated seasonal component for each seasonal regime[4]. Standard errors are obtained using the HC covariance matrix in the corresponding regression over the regime defined by the appropriate estimated break dates. Where relevant, the graphs showing the seasonal components are line-type-coded with the first regime (that is, the sub-sample to the first break date) in solid line, the second in dashes and the third in dots.

Table 1 provides structural break test results for the mean, seasonality (if not already seasonally adjusted), autoregressive parameters and volatility in its first four panels. The last panel reports the convergence statistics of the Bataa et al. (2014); the number of iterations for outer (and inner) loop. Table 2 shows the break dates and the respective component's regime-specific estimates based on the breaks and also the estimates ignoring those breaks. 95% confidence interval for the break dates and heteroskedasticity robust standard errors are also reported in brackets. There are five country-columns, each split into further growth and inflation sub-columns. I discuss the results for seasonality first, then dynamics and finally level and volatility.

The null hypothesis of no structural break in the seasonal pattern of Japanese inflation against an alternative of unknown number of breaks is rejected soundly as WDmax statistic of 22.34 is significantly higher than the critical value of 14.55 (panel B of table 1). The sequential test indicates that there are two seasonal breaks, which occur in the first quarter of 1978 and the last quarter of 1999 (panel B of table 2)[5]. As the right-hand side of panel d) in Figure 1 reveals, the first quarter decline in prices started in 1978. Since then although the overall pattern of seasonality is largely intact, the magnitude of the seasonal oscillations has reduced in the new millennia. Bataa et al.'s (2014) study monthly of G7 inflation found that there are also two seasonality breaks in Japanese inflation; in September 1984 and May 1999, the latter of which is very close to the one in this study.

I find no statistically significant structural change in South Korean, Russian and Mongolian inflation seasonality; prices peak in the first quarter and drop subsequently throughout the year for the former two countries (figures 2 and 4) while inflation is highest in the first half of the year and declines only in the autumn in Mongolia. As for China, there is a marginally significant structural break in inflation seasonality; after 2009 prices neither drop in the third quarter, nor increase in the last quarter, as much as they used to before that (figure 3). In terms of the size of seasonality, measured by their standard deviations, the countries rank from low to high order as Japan, South Korea, China, Russia and then Mongolia.

Remarkably large seasonal fluctuations for Russian and Mongolian growth in figures 4 and 5 contain two structural breaks each with similar timing, perhaps both reflecting their dependence on fuel and energy products as their main economic growth. In both countries, growth drops in the first quarter and recovers in the second quarter (and also third quarter for Russia's case). The magnitude of the drop in the first quarter has intensified in Russia, first in the second quarter of 2003 and again in the third quarter of 2011 while the seasonality is overall declining for Mongolia, although starting from an extremely high level. The magnitude of the Russian seasonal fluctuations is a drop of 12.92% in the first quarter, and seasonal recoveries of 3.92%, 8.04% and 0.96% respectively in the remaining quarters of the year before 2003. Then the pattern changes into a drop of 15.04% in the first quarter and recoveries of 6.66%, 7.47% and 0.91% in the following quarters. After 2010, the drop is 18.55% and the recoveries are 6.31%, 6.45% and 5.79%. The comparative seasonal drop and recoveries are -43.56%, 47.34%, -8.49%, 4.71% over the quarters before 2003, -42.02%, 40.21%, -5.31%, 7.13% afterwards and -39.26%, 36.98%, 0.82% and 1.47% after 2011 in Mongolia.

It is also interesting to find no growth persistence break for all the countries (panel C of Table 1). This is line with the earlier literature that finds low growth persistence (see e.g. Easterly et al.). The growth persistence is statistically insignificant for Japan and South Korea, but significant for the other countries (panel C of Table 2). Inflation persistence, measured by the sum of autoregressive coefficients declines in China in the third quarter of 2011 and is now the lowest in the GTI area, while that of Mongolia increased after a quarter[6].

The null hypothesis of a constant mean is rejected for all series except in Russian growth and Mongolian growth and inflation. The sequential tests indicate that there are two breaks for Japan and one break for China in their levels of growth and inflation. The number of breaks in growth and inflation does not match for South Korea and Russia; 1 and 2 for the former and 0 and 2 for Russia. The 95% confidence intervals for the break dates much tighter than the seaonality breaks.

Japanese growth declines in the second quarter of 1973, after the first oil shock, from 2.31% per quarter to 1.03%, and again in the last quarter of 1990, after the burst of its asset price bubble. The growth is mere 0.24% after this break, which is at least 3 times lower than the post-60 average growth of 0.94%, obtained by ignoring the breaks. Interestingly, South Korea maintained its miracle growth rate of 2.21% up until 2001. This is in contrast to Ben-David and Papell (1998) who found, using annual real per capita GDP, growth slowdowns, in 1967 for Japan and in 1979 for South Korea using data from 1950 to 1990. However their methodology allows for only one break. Bai and Perron (1998, 2003) show that when there are more than one breaks such a procedure can be misleading. Jones and Olken (2008) and Kar et al. (2012) found two down-breaks in 1970 and 1991 for Japan, which are very close to what I find. For South Korea, Jones and Olken (2008) found an up-break in 1962 using a sample that ends in mid 2000s. Kar et al. (2012) reported two up-breaks in 1962 and 1982 and two down-breaks, in 1991 and 2002 for South Korea. But as explained in the Introduction they do not consider the statistical significance of their breaks.

There is some evidence that the growth regimes precede those of inflation for Japan and South Korea, in contrast to Eichengreen et al.'s (2012) claim. The second Japanese growth decline occurs less than 3 years before the inflation decline, while 2001 growth slowdown of 1.28 percentage point in South Korea is followed within a quarter by 0.52 percentage drop in its level of inflation. Interestingly, Bataa et al. (2014) also found two down-breaks in Japanese inflation; the first one is in January 1981 and the second one in 1990s. The level of inflation is breaking down in both China and Russia but remains at stubbornly high level in Mongolia.

Eichengreen et al. (2012) note that a special anxiety is attached to the question of how and when Chinese growth might slow. This study finds evidence that the slowdown might have already occurred and is dated in the third quarter of 2011. If this break is ignored one would wrongly calculate the average annual growth is 8.8% per annum since 1995, but as Table 2 indicates the growth has declined from 9.56% before the break to 6.9% afterwards. This could indeed be associated with the increased power of Bataa et al.'s (2014) testing strategy.

Panel Ds of Tables 1 and 2 indicate that volatility regimes are most common. There are 6 and 7 of them in growth and inflation, respectively. While most other countries' growth volatilities are entering more stable regimes, Japanese one is substantially higher in the latest regime that started in the last quarter of 2006, influenced by the GFC, yet the inflation volatility is still subdued since 1979. Inflation volatilities are also mostly subdued except in Russia, where the inflation has become more volatile after the first quarter of 2012, perhaps reflecting the Western sanctions.

The volatility for inflation first declines in 1981 for South Korea followed by a decline for its growth in 1989 (panel D, Table 2). The inflation volatility further declines in 2000, which is again followed by a growth volatility decline after 3 years. Such close relationship applies for China and to a lesser extent for Russia. Given that inflation volatility is often used as policy instability (see e.g. Eichengreen, Park and Shin, 2012) it could be that inflation volatility precedes growth volatility. This hypothesis should be an interesting topic for future research, perhaps using the multivariate approach as in Bataa et al. (2013).

The share in the total volatility of seasonal origin has increased for all inflation series. While around a quarter of the total volatility used to be attributed to the seasonality in Japan and South Korea before the 1980s, more than a half is due to such forces in the new millennia. It is particularly high in otherwise tranquil Chinese inflation where it accounts for 82% of the total volatility after the third quarter of 2011. As for the Russian and Mongolian growth rates, more than 80% their volatility is driven by seasonal fluctuations. As the business cycle component of Russian quarterly growth volatility declines, the seasonal cycle's share has increased; 92% of its total volatility is being driven by seasonality since the second quarter of 2013.

4. Conclusions

This paper uses a newly developed iterative procedure for the decomposition of GTI growth and inflation into level, seasonality and dynamic components, together with conditional volatility, when these components are permitted to exhibit distinct multiple structural breaks over the sample period and outliers are taken into account. To my knowledge, such a flexible procedure has not been used previously in the.

The paper delivers evidence that important structural changes occurred not only in the level (mean) of growth and inflation, but also in their seasonal pattern, and volatility. These results highlight the importance of considering different types of structural breaks in the current debate of implications of Chinese growth slowdowns (see, for example, Pritchett and Summers, 2014) for Northeast Asian economies. More specifically, just as did the growth slow down in the second quarter of 1973 and in the last quarter of 1990 in Japan and also in the first quarter of 2001 in South Korea, I find a statistically significant growth slowdown in the third quarter of 2011 for China.

The paper also sheds light on the sources of inflation volatility and documents that seasonality is emerging as the dominant source of volatility in an era of reduced business cycle volatility. This highlights the importance of rethinking the current practice of relying too much on seasonal adjustment techniques such as X-13 or DEMETRA before analysing the growth and inflation behaviour as these seasonal filters are removing too much of the real life or relevant fluctuations.

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Table 1. Structural Break Tests in Components of GDP Growth and CPI Inflation

	Japan 1960q2-2018q3		South Korea 1960q2-2018q3		China 1993q2-2018q3		Russia 1995q2-2018q3		Mongolia 1995q2-2018q3	
	growth	inflation	growth	inflation	growth	inflation	growth	inflation	growth	inflation
A. Mean										
WDmax	102.52*	202.16*	48.19*	110.37*	51.73*	33.60*	8.93	64.31*	7.18	1.50
Seq(2|1)	26.44*	38.04*	2.68	24.84*	0.20	0.19		24.96*		
Seq(3|2)	0.45	0.02		0.0				0.0		
B. Seasonality										
WDmax	N.A.	22.34*	N.A.	7.04	N.A.	13.29*	87.06*	4.40	41.31*	3.18
Seq(2|1)		19.84*				7.67	18.32*		50.30*	
Seq(3|2)		0.0								
C. AR lags	0	3	3	4	4	2, 0	1	1	3	0, 4
WDmax	1.83 (9.4)	9.63 (14.6)	13.07 (14.6)	14.04 (16.9)	5.32 (15.5)	14.34*(10.8)	4.4 (8.24)	1.42 (10.8)	10.72(13.3)	19.8*(13.3)
Seq(2|1)						2.17 (11.70)				4.35 (16.70)
D. Volatility										
WDmax	15.68*	64.22*	70.42*	140.29*	58.63*	45.55*	11.44*	23.74*	3.62	24.47*
Seq(2|1)	15.73*	5.98	55.53*	23.40*	2.63	6.78	6.63	21.49*		6.74
Seq(3|2)	4.27		4.65	0.0				1.30		
E. # iteration	2 (2)	6 (2)	3 (2)	5 (2)	3 (2)	19 (2)	19 (2)	8 (2)	3 (2)	5 (3)

Notes: Decomposition using the iterative method of Bataa *et al*. (2014), with breaks detected using Qu and Perron's (2007) test. * indicates a rejection of the null hypothesis with 95% confidence. The null hypothesis of *WDmax* test is no structural break while the alternative is up to M breaks. If the null is rejected then *Seq(i+1|i)* test is sequentially applied to determine the exact number of breaks, starting with a null of 1 break against an alternative of 2, until the null is not rejected. Asymptotic 5% critical values of *WDmax*, *Seq*(2|1) and *Seq*(3|2) tests for the mean and volatility are 9.42, 9.82 and 10.72, respectively with trimming 20% and M = 3. The corresponding values for the seasonality are 14.55, 15.46 and 16.34 respectively, with 20% trimming and M = 3 (13.26 and 14.34 with 30% trimming and M = 2). Those for the autoregressive parameters (trimming parameter and M are the same with seasonality) are reported next to the test statistics in brackets in panel C as the lag orders differ across variables. The autoregressive order of the dynamic component is selected by the AIC criterion and is reported in panel C. Finally, the numbers required to achieve convergence on the main and (sub) loops are shown. If the iteration converges to a two cycle (when 19) it reports results based on Bataa *et al*. (2016)'s information criteria.

Table 2. Regimes in Components of GDP Growth and CPI Inflation and Seasonality Share in the Total Volatility

	Japan		South Korea		China		Russia		Mongolia	
	growth	inflation	growth	inflation	growth	inflation	growth	inflation	growth	inflation
A. Mean break dates	**73q2**	**80q4**	**01q1**	**81q4**	**11q3**	**98q3**		**01q3**		
	(72q1-74q3)	(80q1-81q3)	(97q3-04q3)	(81q1-82q3)	(09q4-13q2)	(98q1-99q1)		(00q4-02q2)		
	90q4	**93q4**		**01q2**				**09q4**		
	(87q3-94q1)	(90q1-97q3)		(88q3-14q3)				(08q1-11q3)		
Regime means (s.e.)	2.31 (0.16)	1.70 (0.10)	2.21 (0.16)	3.29 (0.22)	2.39 (0.09)	2.37 (0.31)		4.62 (0.27)		
	1.03 (0.13)	0.51 (0.05)	0.93 (0.10)	1.13 (0.09)	1.71 (0.03)	0.51 (0.07)		2.81 (0.10)		
	0.24 (0.09)	0.06 (0.04)		0.61 (0.05)				1.68 (0.18)		
	[0.94 (0.08)]	[0.73 (0.06)]	[1.82 (0.12)]	[1.77 (0.12)]	[2.20 (0.07)]	[0.89 (0.11)]	[0.69 (0.18)]	[2.84 (0.16)]	[1.64 (0.42)]	[2.55 (0.35)]
B. Seasonality break dates	N.A.	**78q1**	N.A.		N.A.	**09q1**	**03q2**		**03q1**	
		(74q1-82q1)				(03q3-14q3)	(01q2-05q2)		(01q1-05q1)	
		99q4					**10q3**		**11q3**	
		(91q4-07q4)					(09q3-11q3)		(10q1-13q1)	
Seasonal St.Dev.	N.A.	0.41	N.A.		N.A.	0.90	8.42		34.38	
		0.52				0.64	9.66		32.19	
		0.26					11.17		28.00	
		[0.33]		[0.61]		[0.76]	[9.23]	[0.86]	[30.10]	[2.91]
C. Dynamic break dates						**11q3**				**11q4**
						(09q3-13q3)				(09q4-13q4)
Persistence (s.e.)						0.80 (0.07)				0.46 (0.33)
						0.15 (0.24)				0.69 (0.21)
	[0.02 (0.09)]	[0.63 (0.11)]	[-0.15 (0.14)]	[0.46 (0.14)]	[0.49 (0.19)]	[0.78 (0.07)]	[0.37 (0.17)]	[0.47 (0.13)]	[-1.24 (0.25)]	[0.46 (0.32)]

Table 2. Continued

	Japan		*South Korea*		*China*		*Russia*		*Mongolia*	
	growth	*inflation*	*growth*	*inflation*	*growth*	*inflation*	*growth*	*inflation*	*growth*	*inflation*
D. Volatility break dates	**90q3**	**79q3**	**89q2**	**81q1**	**11q1**	**11q1**	**13q2**	**00q4**		**09q3**
	(84q1-93q3)	(65q4-79q4)	(80q2-89q4)	(67q2-81q2)	(07q3-11q2)	(07q1-11q2)	(01q4-14q1)	(96q4-01q1)		(05q1-10q1)
	07q2		**04q1**	**00q4**				**12q1**		
	(04q3-11q2)		(04q1-05q1)	(95q3-03q1)				(11q3-16q2)		
Regime shock St. Dev	1.09	0.92	2.27	2.06	0.76	0.94	2.01	1.81		4.25
	0.66	0.42	1.21	0.80	0.18	0.28	1.07	0.58		1.92
	1.24		0.79	0.45				1.31		
	[1.01]	[0.62]	[1.73]	[1.29]	[0.62]	[0.78]	[1.81]	[1.10]	[4.09]	[3.41]
E. Seasonality share	N.A.	0.27	N.A.	0.22	N.A.	0.31	0.80	0.29	0.85	0.40
in total volatility		0.32		0.42		0.38	0.82	0.39	0.87	0.52
		0.37		0.55		0.70	0.84	0.56	0.88	0.59
		0.54				0.82	0.92			
		[0.44]		[0.56]		[0.45]	[0.82]	[0.51]	[0.88]	[0.63]

Notes: Estimates of the break dates and of the components of (1) in the resulting regimes. 95% confidence intervals for the break dates and heteroscedasticity robust standard errors are reported in brackets. The quantities that are estimated ignoring the breaks are in square parentheses.

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[1] See http://www.tumenprogramme.org for details. Such development is extremely important for Mongolia as imports from China, Russia, Japan and South Korea constitute 41.8%, 36.8%, 11.9% and 5.6% of the total respectively, while 96% and 1.3% of the total exports go to China and Russia as of 2018.

[2] According to the IMF World Economic Outlook-2018, the World, Chinese, Japanese, South Korean, Russian and Mongolian GDP were 84835462, 13457267, 5070626, 1655608, 1576488, 12724 million USD respectively.

[3] Data for China, Japan, South Korea and Russia are obtained from the OECD (www.oecd.org). Chinese growth rate prior to the first quarter of 2011 is not available there, hence obtained from Bataa *et al.* (2018). Russian growth rate is also not available from the OECD prior to the second quarter of 2003, hence seasonally unadjusted series is obtained from the Federal State Statistical Office of the Russian Federation (www.gks.ru) and both Mongolian series are from the National Statistical Office of Mongolia (www.1212.mn). The lack of high quality seasonally unadjusted raw growth rate data that goes back to 1960 was unavailable for Japan and Korea; hence I used OECD's seasonally adjusted data.

[4] The procedure detected the following outliers: 74q2 in Japanese inflation, 98q2 in growth, and 63q4, 64q2, 64q4, 74q2 and 80q2 in inflation for Korea, 95q3-96q1 and 98q4-99q2 in inflation for Russia and 95q4 in inflation for Mongolia. These outliers are associated with well-known historical events such as the first oil shock, the transition related shock therapy consequences and Russian debt crisis of 1998.

[5] Note that the growth rates are seasonally adjusted for Japan, Korea and China, thus indicated with N.A. in the tables; see OECD and Bataa *et al*. (2018).

[6] When the autoregressive lag in panel C of Table 1 is 1, the AR (1) coefficient itself is the persistence.

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