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Multivariate Filter Estimation and ARDL Model Analysis of China's Potential Output*

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Abstract

In this paper, we apply a new multivariate filter approach developed by Borio et al. (2014) to estimate China's potential output. Furthermore, we build an ARDL model to analyze the influence on potential growth caused by important factors that contribute to estimation and China's development. Our results show that the current economic slowdown is not a cyclical phenomenon and China's potential growth has declined since 2010. We also show that fix asset investment and trade, which have a long run relationship with potential output, exert negative long-run effect on potential growth justifying the implementation of China's recent supply-side reforms.

JEL Classification: C32 C51 E23

Keywords: Potential output, Economic growth, Multivariate filter, ARDL

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1. Introduction

Three decades of China's economy rapid growth is a miracle of world economic development and also becomes a hot academic topic among researchers. However, China's growth has slowed down for almost four years, manifesting the ineffectiveness of government's stimulus policies. Yet it's unclear whether the persistent decrease in actual growth implies a decline of potential growth. Due to the downturn of economy, China is initiating reforms focusing on the supply side of the economy. These reforms include cutting housing inventories, tackling debt overhang, eliminating superfluous industrial capacity and other measures, while few have mentioned the impact of two demand-side factors, i.e. investment and trade, on China's potential growth in past and yet leaving questions for the validity of supply-side reform. To answer these questions, we apply a new multivariate filter approach to estimate China's potential output. Further, we adopt an auto regressive distributed lag(ARDL) model to analyze the influence of investment and trade on China's potential growth.

Potential output, defined as the output that could be achieved without giving pressure on inflation or output level realizing full utilization of economic inputs (Okun, 1962; Mishkin, 2007), is a critical notion in macroeconomics. Both short-run policymaking and long-term welfare are associated with the potential output and deviations from it. However, such evaluation of output gap and potential growth is challenging since they are unobservable. Thus economists developed various methods to estimate the potential output. The conventional and prevalent technique is univariate filters (Beverigde and Nelson，1981；Baxter and King，1999；Hodrick and Prescott，1997) which take time series as the combination of different periodic components and analyze them purely from a statistical perspective. Owing to its simple procedure and moderate data requirements, it has been used for decades and is still popular in emerging market economies. On the other hand, to overcome the drawbacks of lacking economic information and strong assumption about output gap, multivariate filter approaches equipped with structural economic relationships (Beneš, Jaromír, et al, 2010; Blagrave, Patrick, et al, 2015) and financial imbalance factor(Borio, Disyatat, and Juselius, 2013) are developed. However most multivariate filter methods could not be adapted to developing countries for two reasons. First, economic relationships, for example the Phillips curve (Nugent, Jeffrey B., and Constantine Glezakos, 1982), may not be satisfied in those countries which makes it insignificant to contain them in the process of estimation. Second, many emerging markets do not provide accurate macroeconomic data about employment rate, inflation deflator and other important information.

In this paper, we aim to avoid issues mentioned above by adopting Borio et al. (2014)'s parsimonious approach and embedding information of fix asset investment and export in observation equation to estimate potential output. Our results show that China's potential growth has been slowed down since 2010 and its actual growth rate fluctuates below the potential rate. The output gap remains positive after government's four-trillion investment plan which had little effect in improving potential growth. Besides, by fitting an ARDL model we find that although fix asset investment and export as driven the actual output growing for a long time, they are not beneficial for increasing the potential output in the long run which reflects structural issues of China's economy and makes it reasonable to implement the supply-side reform focusing on both long run and high quality growth.

2. Methodology and data

The method we applied is based on benchmark HP filter approach. We assume an AR(1) process for output gap and directly add economic information into the observation equation,

$$y_t = y_t^* + \beta\left(y_{t-1} - y_{t-1}^*\right) + \theta' a_t + \varepsilon_{1,t} \tag{1}$$

y_t and y_t^* are actual and potential output respectively. To avoid the situation that output gap becomes a random walk and its cumulative variance goes to infinity, $|\beta|$ needs to be less than one. ε_1 is assumed to be normally distributed with mean zero and variance σ_1^2. a_t is a vector of economic variables that contribute to estimating potential output.

The state equation can be written as

$$\Delta y_{t+1}^* = \Delta y_t^* + \varepsilon_{0,t} \tag{2}$$

where ε_0 is similar as ε_1 but with variance σ_0^2. Equation (2) implies that potential growth is a random walk. With state equation, the corresponding loss function minimization problem for observation equation is

$$\underset{y_t^*}{Min} \sum_{t=1}^{T}\left[\left(\left(\varepsilon_{1,t}\right)^2 + \lambda_1\left(\Delta y_{t+1}^{\ *} - \Delta y_t^*\right)^2\right)\right] \tag{3}$$

The scaling factor, $\lambda_1 = \dfrac{\sigma_1^2}{\sigma_0^2}$ determines the weight between two terms in (3) among which ε_1 depends on both dynamic term and economic variables. To overcome small sample problem, we need to iterate values of λ_1 to make the potential output estimated by multivariate method $y_{MVF,t}^*$ satisfies the condition[1]

$$\frac{\mathrm{var}\left(y_t - y_{HP,t}^*\right)}{\mathrm{var}\left(\Delta y_{HP,t}^* - \Delta y_{HP,t-1}^*\right)} = \frac{\mathrm{var}\left(y_t - y_{MVF,t}^*\right)}{\mathrm{var}\left(\Delta y_{MVF,t}^* - \Delta y_{MVF,t-1}^*\right)} \tag{4}$$

where $y_{HP,t}^*$ is HP filter's estimate.

Allowing for the essential properties of information variables[2], the potentially economic variables include fix asset investment and trade which are widely believed as important forces for China's economic growth (Qiao Yu, 1998). Their annual growth rate are 21.1% and 18% respectively since 1978's initiation of Reform and Opening policy[3] which not merely power China's GDP growth but also improve total factor productivity. In addition, the recent financial crisis and asset boom-bust cycle in many countries show that financial sector can exert influence on real sector

[1] The reason for using condition (4) is that we add dynamic terms in observation equation and may cause the scaling factor setting too little weight on reducing potential output variability compared to standard HP filter. Detailed explanations can be found in Borio et al. (2014).

[2] The properties that make economic variables significant in observation equation include two aspects. One is that variables should be correlated with output at specific frequencies setting by scaling factor and the other one is that variables should have stable means. Thus, we follow Borio et al. (2014)'s method using Cesàro mean to de-mean all economic variables so that they can meet the requirement of the approach.

[3] The growth rates are computed by using the data from "China Statistical Yearbook".

(Claessens et al., 2012). Especially in China, fix asset investment and export are closely related to bank's loan due to the banking oriented financial system and compulsory exchange settlement mechanism. Most part of state owned enterprises funding resource is loan(F. Allen et al., 2005) and tremendous quantity of debt related to banking sector becomes a potential factor for financial imbalance in China nowadays. Thus, we choose fix asset investment, trade and loan as economic variables and embed them into observation equation. We also add export and real estate investment into analyzing process after the estimation.

Table1. Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
GDP	134662.8	140185.4	5234.8	636138.7
Trade	3908.988	3595.006	286.69	11425.9
Fix Asset Investment	32306.86	41227.1	315.36	159620.6
Export	2102.155	1946.158	149.69	6457.64
Real Estate Investment	6393.512	7811.997	29.04	27304.31
Loan	24533.61	26008.02	496.42	97800

The data are quarterly and estimation period is from 1993q1 to 2015q2.Sampleare collected from People's bank of China and CEInet Statistics Database. Seasonality problem is avoided by using X-12 method. And we use Kalman filter to form the likelihood of the system with gamma priors and maximize the posterior density function with respect to parameters[4] and regressors with lags of up to four periods are allowed to go into models.

3. Results and Analysis

By adding different economic information, we find that both fix asset investment and trade contribute to estimate potential output and they are statistically significant when embedded together. Thus, we use model 4 to get the estimates.

Table 2. Estimation Results of Observation Equation

	β	θ_1 Loan	θ_2 Fix Asset Investment	θ_3 Trade	λ_2 Scaling Factor
Model 1	0.9500***	0.0392			6.5100
	（13.5412）	（1.1189）			
Model 2	0.9497***		0.1131**		6.1500
	（9.5754）		（1.9747）		
Model 3	0.9499***			1.8756***	3.2900
	(7.5712)			(6.1723)	
Model 4	0.9480***		0.1013***	1.8016***	6.0500
	（13.5417）		（2.5018）	（14.2544）	

[4] Assumptions for prior mean and standard deviation of auto-regressive parameter and scaling factors are following Borio et al.(2014) and Chang C, Chen K, Waggoner D F, et al.(2015)'s work. As prior distribution, we assume the gamma distribution with standard deviation of 0.3 for all parameters and the prior mean for auto-regressive parameter is 0.65 of which the interval is between 0 and 0.95. Coefficients for economic information variables have prior means equal to 0.4.

Note: ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Numbers in parentheses are t statistics. The notation denotes same meaning in table 3.

Table 3. Results from ARDL Model Estimation

Model 1 ARDL (1,2,2)			
Short Term Effect Coefficients			
$\Delta investment_{t-1}$	0.0099^{***}	$\Delta trade_{t-1}$	0.0546^{*}
	（2.7304）		（1.7832）
$\Delta investment_{t-2}$	0.0067^{*}	$\Delta trade_{t-2}$	0.0375
	（1.8816）		（1.0999）
Long Term Effect Coefficients			
investment	-0.0048^{***}	trade	-0.0864^{***}
	（-3.1207）		（-3.9506）
Bounds Test			
5.1620			
5% Significance Level		1% Significance Level	
I0 Bound	I1Bound	I0 Bound	I1Bound
3.79	4.85	4.41	5.52
Model 2ARDL (1,1,1)			
Short Term Effect Coefficients			
$\Delta investment_{t-1}$	0.0252^{*}	$\Delta trade_{t-1}$	0.0818
	（1.9218）		（1.4628）
Long Term Effect Coefficients			
investment	-0.0309^{***}	trade	-0.0923^{**}
	（-3.7011）		（-2.4097）
Bounds Test			
0.7656			
10% Significance Level		5% Significance Level	
I0 Bound	I1Bound	I0 Bound	I1Bound
3.17	4.14	3.79	4.85

Note: Variables in ARDL model follow the order as GDP, investment and trade. Instead of using fix asset investment and trade as regressors in model 1, we use real estate investment and export in model 2.

Figure 1 shows China's potential output keeps declining since 2010 with real growth rate fluctuating below it. Although government's stimulus plan has slight influence on raising real growth, it was not effective on improving potential growth thus leaving real growth decreasing subsequently. With the knowledge of the trend for potential output, we could tell the slowdown of China's economic growth is not a cyclical phenomenon but a result of potential growth fall.

Figure 1. Potential and Real Growth Rate

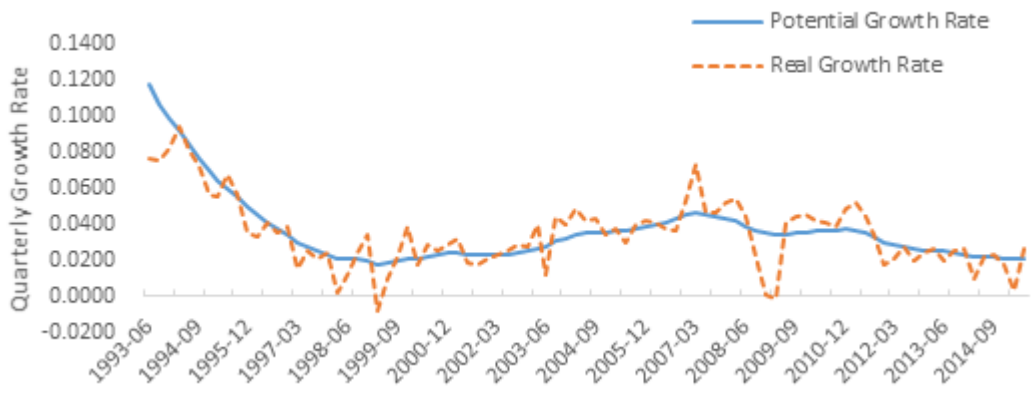
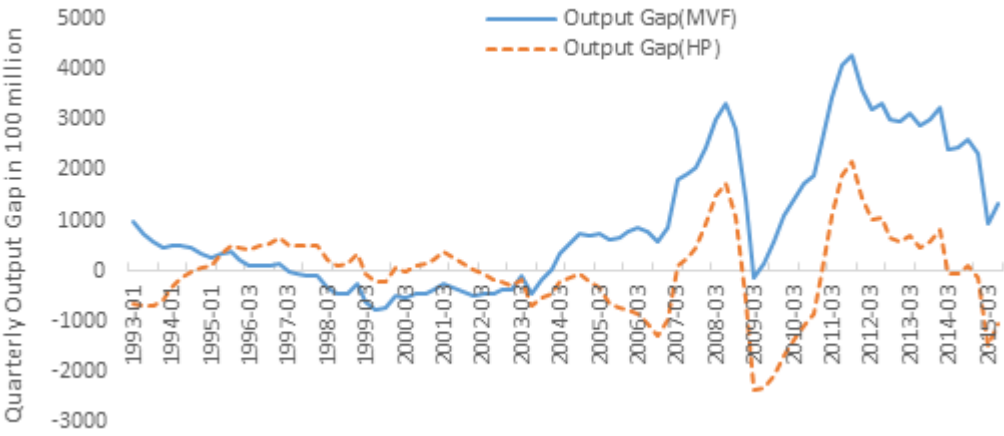


Figure 2 compares multivariate filter approach with standard HP filter results. Large differences appear after 2008's financial crisis. Significant negative output gap emerges in HP filter approach, while it doesn't show up in multivariate filter approach. Taking government four-trillion investment plan into consideration, positive output gap is more in line with China's real performance since China successfully stimulates the demand side in a short time with tremendous government investment following by asset bubble, over-capacity issue and local government debt risk nowadays.

Figure2. Comparison of Output Gaps



To further analyze potential growth, besides total fix asset investment and trade, real estate investment and export are used in ARDL model to examine how the most important components in these two areas affect growth. Meanwhile, we can check the robustness of the regression. Following Pesaran et al.(1999)'s method, the error correction form of ARDL model can be written as,

$$\Delta g_t = c_0 + \sum_{j=1}^{n} a_j \Delta investment_{t-j} + \sum_{j=1}^{n} b_j \Delta g_{t-j} + \sum_{j=1}^{n} d_j \Delta trade_{t-j} + n_1 investment_{t-1} + n_2 g_{t-1} + n_3 trade_{t-1} + \varepsilon_t \quad (5)$$

a_j and b_j measure short-run effects on dependent variable and coefficients n_1, n_2, n_3

represent long term influences. Potential output is set as the dependent variable while investment, trade and lagged value of these variables are independent variables. By using bounds test (Pesaran et al.,2001), the existence of level relationships between these variables are tested. The reason for using bounds test is that it can be well adapted on small sample without the certainty that underlying regressors are trend- or first-difference stationary. The null hypothesis of bounds test are $n_1 = n_2 = n_3 = 0$ .AIC criterion is adopted to obtain lagged rank for independent variables in ARDL model.

The results show that all factors have negative long run effect on potential growth. However, they have positive short run effect, especially when it comes to investment factor. Hence, these factors are beneficial in improving short term economic performance, while they cause path-dependence issue of China's growth and imbalance between internal and external economy which finally harm the long run performance. Besides, fix asset investment, trade and output have long run relationship. Meanwhile, no significant evidence are found for export and real estate investment according to bounds test.

4. Conclusion

We apply a new multivariate filter approach to estimate China's potential output which embeds economic information and avoids estimation problems that other methods may face when used in developing countries. In addition, ARDL models are built to analyze influences on potential output caused by factors that are crucial in China's economy. The results show that China's potential growth has declined since 2010. Besides, fix asset investment and trade have negative long-run effect on potential growth which becomes more serious when focusing on real estate investment and export part. The former two have long-term relationship with potential output and all results show the rationale for the implementation of China's recent supply-side reforms which focus on improving economy structure and potential growth, thus achieving rapid and sound development.

References

Allen, Franklin, Jun Qian, and Meijun Qian. 2005. "Law, finance, and economic growth in China." Journal of financial economics 77(1): 57-116.

Baxter, Marianne, and Robert G. King. 1999. "Measuring business cycles: approximate band-pass filters for economic time series." Review of economics and statistics 81(4): 575-593.

Beneš, Jaromír, et al.2001. "Estimating potential output with a multivariate filter." IMF Working Papers: 1-37.

Beveridge, Stephen, and Charles R. Nelson.1981. "A new approach to decomposition of economic time series into permanent and transitory components with particular attention to measurement of the 'business cycle'."Journal of Monetary economics 7(2): 151-174.

Blagrave, Patrick, et al. "A simple multivariate filter for estimating potential output." No. 15-79. International Monetary Fund, 2015.

Borio, Claudio EV, PitiDisyatat, and Mikael Juselius. 2013. "Rethinking potential output: Embedding information about the financial cycle." BIS Working Papers No. 404.

Borio, Claudio EV, PitiDisyatat, and Mikael Juselius. 2014. "A parsimonious approach to incorporating economic information in measures of potential output." BIS Working Papers No. 442.

Chang, Chun, et al. 2015. "Trends and cycles in China's macroeconomy." No. w21244.

National Bureau of Economic Research.
Claessens, Stijn, M. AyhanKose, and Marco E. Terrones. 2012. "How do business and financial cycles interact?" Journal of International economics 87(1): 178-190.
Hodrick, Robert J., and Edward C. Prescott. 1997. "Postwar US business cycles: an empirical investigation." Journal of Money, credit, and Banking: 1-16.
Mishkin, F (2007): “Estimating potential output.” Speech delivered at the Conference on Price Measurement for Monetary Policy, Federal Reserve Bank of Dallas, 24 May.
Nugent, Jeffrey B., and Constantine Glezakos. 1982. "Phillips curves in developing countries: The Latin American case." Economic development and cultural change 30(2): 321-334.
Okun, Arthur M. 1962. “Potential GNP: its measurement and significance.” American Statistical Association, Proceedings of the Business and Economic Statistics Section: 98–104.
Pesaran, M. Hashem, Yongcheol Shin, and Ron P. Smith. 1999. "Pooled mean group estimation of dynamic heterogeneous panels." Journal of the American Statistical Association 94(446): 621-634.
Pesaran, M. Hashem, Yongcheol Shin, and Richard J. Smith. 2001."Bounds testing approaches to the analysis of level relationships." Journal of applied econometrics 16(3): 289-326.
Yu, Qiao. 1998. "Capital investment, international trade and economic growth in China: evidence in the 1980–1990s." China Economic Review 9(1): 73-84.