No. 9204

DOES AGGREGATE OUTPUT HAVE A UNIT ROOT?

by

Mark A. Wynne*

April 1992

Research Paper

Federal Reserve Bank of Dallas

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Abstract: Gross National Private Product is a more appropriate empirical counterpart for the theoretical concept of aggregate output than GNP. The two series have different stochastic properties over the past 100 years.

*Senior Economist, Federal Reserve Bank of Dallas. The views expressed in this article are solely those of the author and should not be attributed to the Federal Reserve Bank of Dallas or to the Federal Reserve System.

Does Aggregate Output Have a Unit Root?

1. Introduction

Since the seminal paper of Nelson and Plosser (1982), economists have been concerned with the appropriate characterization of the trends that seem to be a feature of almost all aggregate time series. On the basis of an augmented versions of the tests for unit roots suggested by Dickey and Fuller (1979), Nelson and Plosser argued that most aggregate series are better characterized as having stochastic as opposed to deterministic trends. Their findings motivated a rethinking of the traditional trend-cycle decomposition of movements in aggregate activity, and contributed to the switch in emphasis among some economists from monetary to real models of the business cycle. Their findings also stimulated a plethora of research on testing for unit roots. The issue of whether aggregate output contains a unit root is still essentially unresolved, and in the view of some may be unresolvable [see, e.g., Christiano and Eichenbaum (1990), DeJong and Whiteman (1991)].

The objective of this paper is not to propose another test for unit roots or to apply existing tests to some new dataset. Rather, I want to argue that GNP is not the concept of aggregate output that best corresponds to the concept of aggregate output found in most theoretical models. This point applies a fortiori to neoclassical real business cycle models of the type analyzed by Kydland and Prescott (1982) and King Plosser and Rebelo (1987).[1]

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[1]Note that the various studies of long term U.S. economic growth by Edward Denison, such as Denison (1985), avoid this issue by focusing on the output of the nonresidential business sector.

It is Gross National Private Product (GNPP) that bears a closer resemblance to the aggregate output concepts found in these models.[2] If we employ the popular Augmented Dickey-Fuller (ADF) test to look for unit roots in a 100-year sample, we find evidence against the unit root hypothesis in the GNP series but not in the GNPP series.

2. Analysis

GNP can be broken down in many ways. The split I want to focus on is that between Gross National Private Product (GNPP) and Gross National Government Product (GNGP). The inclusion of government product in the GNP aggregate is motivated by the idea that the government produces an output of some sort that is valued (in a utility sense) by the private sector. Since the output of the government sector is unobservable, it is estimated as the total compensation of employees in the government sector [see U.S. Department of Commerce: Bureau of Economic Analysis (1985)]. Government product will therefore tend to increase in periods when government payrolls expand. The most dramatic such increases occur during wars, when the government typically relies on conscription at below market wages to increase the size of the military. At war's end the conscripts are released back into the private sector. The large size of these temporary movements relative to the typical peacetime fluctuations in government employment may produce a pattern of mean reversion in aggregate output that is not present in the private component thereof.

Data on GNP and GNGP on an annual basis are from U.S. Department of

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[2]See Wynne (1991) for a discussion of how the distinction between GNP and GNPP affects the analysis of fiscal policy in these models.

Commerce: Bureau of Economic Analysis (1986) and various issues of the Survey of Current Business for the period from 1929 to 1990. Prior to 1929, data can be obtained from Kendrick (1961).[3] The data from Kendrick are converted to 1982 prices using 1929 as the year of overlap. All variables are measured in per capita terms, where population is defined as the total population.[4]

The ADF test was carried out by estimating the model

$$z_t = \alpha + \gamma t + \rho_1 z_{t-1} + \sum_{j=1}^{k} \rho_{j+1}(z_{t-j} - z_{t-j-1})$$

where z_t denotes the natural log of the series. The results are reported in Table 1 for various values of k. All estimation was carried out using observations for the period 1894-1990, giving a sample of 97 observations. The critical values from Table 8.5.2 of Fuller (1976) for n = 100 were used to decide between rejection and acceptance of the null hypothesis H_0: $\rho_1 = 1$.

For all values of k, the null hypothesis of a unit root is rejected at the 5% level for GNP. But when the government component of GNP is removed from the aggregate, we are no longer able to reject the unit root null. Looking at government purchases of goods and services (which includes the government component of GNP) we are able to reject the null of a unit root at the 1% level for k=1, at the 2.5% level for k=3, and at the 5% level for k=2. Government sector GNP (GNGP), which is simply the compensation of employees

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[3]Alternative estimates of pre-1929 GNP are available in Balke and Gordon (1989) and Romer (1989). The results in this paper are essentially unchanged when we use these alternative measures of GNP.

[4]The results are unaffected if we use total resident population. The difference between the two measures is armed forces overseas. While changes in the number of military personnel stationed abroad are usually small, during wartime they can be and are significant.

component of aggregate government purchases of goods and services, does not exhibit the strong rejection of the unit root hypothesis that we might have expected given the differences between GNP and GNPP. For k=1 we can reject the null of a unit root at the 5% level, while for k=2 we reject at the 10% level. It would appear that the strong mean reversion that we find in aggregate government purchases of goods and services reflects the behaviour of government purchases of private sector GNP. This is borne out by the strong rejection of the unit root null for this series for all choices of k.

There is an obvious explanation for the relatively weak rejection of the unit root null for the GNGP series. As with the government purchases of private sector GNP, the largest variation in this series is during wartime. If movements in this series primarily reflect conscription of workers into the military at below market wages, this series will be undermeasured for the war years. I am currently looking at ways to correct this series to allow for the effects of conscription.

3. Summary and Conclusions

While certain caveats must apply to tests about the stochastic structure of prewar GNP given the way these series were constructed [see Jaeger (1990)] the findings reported here do suggest that there is an important distinction to be made between GNP and GNPP. The ADF test rejects the hypothesis of a unit root in GNP for the period 1894-1990. By contrast the same test is unable to reject the hypothesis of a unit root in GNPP over the same period. Since I use the standard estimates of government product which do not correct for the effects of conscription, the results reported here are conservative. It is reasonable to suspect that consistent measurement of government product

during wartime by valuing the services of conscripts at their market wage would strengthen the findings reported above.

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Table 1

ADF Tests for Unit Roots

Series	k	$\hat{\rho}_1$	$t(\hat{\rho}_1)$	s.e.
GNP	3	0.775	-3.74**	0.055
	2	0.782	-3.93**	0.054
	1	0.804	-3.79**	0.054
Private Sector GNP	3	0.826	-3.08	0.053
	2	0.845	-2.87	0.054
	1	0.849	-2.94	0.053
Government Purchases of Goods and Services	3	0.735	-3.88**	0.176
	2	0.776	-3.48**	0.178
	1	0.735	-4.56***	0.179
Government Sector GNP	3	0.846	-2.84	0.127
	2	0.838	-3.20*	0.126
	1	0.814	-4.02**	0.127
Government Purchases of Private GNP	3	0.569	-4.70***	0.287
	2	0.658	-3.93***	0.295
	1	0.596	-5.27***	0.297

Notes to Table 1: z_t is the natural log of the series divided by total population. Data are in 1982 dollars and are from U.S. Department of Commerce: Bureau of the Census (1975), U.S. Department of Commerce: Bureau of Economic Analysis (1986), various issues of the Survey of Current Business, and Kendrick (1961). Data from Kendrick are converted to 1982 dollars using 1929 as the year of overlap. $t(\hat{\rho}_1)$ is the ratio of $\hat{\rho}_1 - 1$ to the standard error of $\hat{\rho}_1$. * denotes rejection of the null hypothesis H_0: $\rho_1 = 1$ at the 10% level using critical values from Fuller (1976); ** denotes rejection at the 5% level; *** denotes rejection at the 1% level.

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