

Avoiding PPNR Model Mis-Specification from Spurious Correlation Failures

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Novantas is devoted to PPNR stress testing model improvement. As a follow up of an earlier article "Autoregressive Error Terms in PPNR Balance Models", this article describes a bug in the SAS PROC AUTOREG procedure we uncovered during 2015 PPNR model development. We identified that models with no serial correlation fail the Godfrey serial correlation test in the PROC AUTOREG procedure when also performing certain stationarity tests. This article outlines the details of our research into this bug, presents a simple fix, and documents sample code which can be used in PPNR model validation documentation.

PROBLEM: MODELS WITH NO SERIAL CORRELATION FAILING SERIAL CORRELATION TESTS

Novantas PPNR modelers examine both Durbin-Watson and Godfrey (two serial correlation tests provided by PROC AUTOREG) to test for serial correlation. Recently, we found ourselves facing a conundrum: a set of seemingly well-specified models passed Durbin-Watson but failed Godfrey. And when we say failed, they failed: p-values were always $< .0001$. This says that we reject the null hypothesis that there is no serial correlation with $> 99.9999\%$ confidence.

This is a nonsensical result because even though Godfrey is generally a more powerful test than Durbin-Watson in the realm of PPNR time series models, these two tests should not be so divergent. Godfrey's strength comes in its ability to evaluate serial correlation of any order whereas Durbin-Watson is designed to evaluate presence of serial correlation of order 1 (and thus produces weaker results at higher orders). Since it is straightforward to make a theoretical case for meaningful 2-month, quarterly, semi-annual, or annual lags in PPNR balance models, we prefer Godfrey as our default serial correlation test. Nevertheless, the differences between the two test results should rarely be wide. After further investigation, we discovered this was a bug in the SAS PROC AUTOREG procedure: the Godfrey serial correlation test will always fail if the Philips Perron or KPSS stationarity tests are run in the same PROC AUTOREG statement.

Below is a real-life example. The following tables show a model that passes Durbin-Watson on all orders but fails Godfrey badly. Passing criteria for Durbin-Watson is for $\text{Pr} < \text{DW}$ and $\text{Pr} > \text{DW}$ to be between 0.05 and 0.95; passing criterion for Godfrey is for $\text{Pr} > \text{LM}$ to be greater than 0.05.

DURBIN-WATSON				GODFREY		
ORDER	DW	PR < DW	PR > DW	ALTERNATIVE	LM	PR > LM
1	1.9902	0.4637	0.5363	AR(1)	61.064	<.0001
2	1.8585	0.267	0.733	AR(2)	61.0648	<.0001
3	1.7053	0.1406	0.8594	AR(3)	61.1112	<.0001
4	2.0052	0.6104	0.3896	AR(4)	61.1145	<.0001
5	1.7073	0.2189	0.7811	AR(5)	61.1516	<.0001
6	1.4939	0.0589	0.9411	AR(6)	61.2225	<.0001
7	1.7874	0.4218	0.5782	AR(7)	61.2279	<.0001
8	1.569	0.1755	0.8245	AR(8)	61.2543	<.0001
9	1.736	0.4579	0.5421	AR(9)	61.2899	<.0001
10	2.0698	0.9035	0.0965	AR(10)	61.35	<.0001
11	1.5839	0.3377	0.6623	AR(11)	61.3523	<.0001
12	1.5008	0.177	0.823	AR(12)	61.3876	<.0001

RESOLUTION: EVALUATE THE MODEL TWICE

However, this is only the case when the *stationarity* option is specified as "PP" or "KPSS". If the stationarity option is excluded, the model passes Godfrey . A simple fix is to run the `PROC AUTOREG` statement twice: once testing Godfrey, and once testing for stationarity.

With the stationarity option excluded, our model above correctly demonstrates that serial correlation is not statistically identifiable. Note that Durbin-Watson results are unchanged but the model passes Godfrey.

DURBIN-WATSON				GODFREY		
ORDER	DW	PR < DW	PR > DW	ALTERNATIVE	LM	PR > LM
1	1.9902	0.4637	0.5363	AR(1)	0.427	0.5135
2	1.8585	0.267	0.733	AR(2)	0.7939	0.6724
3	1.7053	0.1406	0.8594	AR(3)	0.8854	0.829
4	2.0052	0.6104	0.3896	AR(4)	2.1891	0.701
5	1.7073	0.2189	0.7811	AR(5)	2.966	0.7052
6	1.4939	0.0589	0.9411	AR(6)	3.3221	0.7675
7	1.7874	0.4218	0.5782	AR(7)	3.3522	0.8506
8	1.569	0.1755	0.8245	AR(8)	4.7943	0.7793
9	1.736	0.4579	0.5421	AR(9)	6.6055	0.6781
10	2.0698	0.9035	0.0965	AR(10)	7.1451	0.7117
11	1.5839	0.3377	0.6623	AR(11)	7.2324	0.78
12	1.5008	0.177	0.823	AR(12)	8.083	0.7786

EXAMPLE: CODE FOR VALIDATION DOCUMENTATION

The following code replicates the problem. The first block creates an illustrative dataset exhibiting serial correlation (note: the code extract was pulled out of and edited slightly from this training module: http://support.sas.com/documentation/onlinedoc/ets/ex_code/132/autgs.html). The second and third blocks are code to run PROC AUTOREG with and without the Philips Perron stationarity test.

```
/* Develop dataset */
data a;
    ul = 0; ull = 0;
    do time = -100 to 360;
        u = + 1.3 * ul - .5 * ull + 2*rannor(12346);
        y = 10 + .5 * time + u;
        if time > 0 then output;
        ull = ul; ul = u;
    end;
run;

/* Run autoreg model, WITH PP test */
proc autoreg data = a;
    model y = time / nlag=2
        dw=12 dwprob normal Godfrey=12 archtest=(qlm,lk)
        stationarity=(adf,pp);
run;
```

Output:

DURBIN-WATSON				GODFREY		
ORDER	DW	PR < DW	PR > DW	ALTERNATIVE	LM	PR > LM
1	2.0278	0.5836	0.4164	AR(1)	357.0777	<.0001
2	1.8817	0.1305	0.8695	AR(2)	357.0915	<.0001
3	2.0844	0.8037	0.1963	AR(3)	357.0921	<.0001
4	2.086	0.8222	0.1778	AR(4)	357.0932	<.0001
5	1.9168	0.2642	0.7358	AR(5)	357.0933	<.0001
6	1.9508	0.3996	0.6004	AR(6)	357.0951	<.0001
7	1.9617	0.4609	0.5391	AR(7)	357.0952	<.0001
8	1.9086	0.2916	0.7084	AR(8)	357.1044	<.0001
9	2.0149	0.6963	0.3037	AR(9)	357.1105	<.0001
10	2.0735	0.8694	0.1306	AR(10)	357.1272	<.0001
11	1.9181	0.3825	0.6175	AR(11)	357.1358	<.0001
12	1.7182	0.0155	0.9845	AR(12)	357.1414	<.0001

```
/* Run autoreg model, WITHOUT PP test */
proc autoreg data = a;
    model y = time / nlag=2
        dw=12 dwprob normal Godfrey=12 archtest=(qlm,lk)
        stationarity=(adf);
run;
```

Output:

DURBIN-WATSON				GODFREY		
ORDER	DW	PR < DW	PR > DW	ALTERNATIVE	LM	PR > LM
1	2.0278	0.5836	0.4164	AR(1)	0.3582	0.5495
2	1.8817	0.1305	0.8695	AR(2)	2.689	0.2607
3	2.0844	0.8037	0.1963	AR(3)	2.874	0.4115
4	2.086	0.8222	0.1778	AR(4)	3.5867	0.4648
5	1.9168	0.2642	0.7358	AR(5)	3.6722	0.5975
6	1.9508	0.3996	0.6004	AR(6)	3.8337	0.6992
7	1.9617	0.4609	0.5391	AR(7)	3.8563	0.7962
8	1.9086	0.2916	0.7084	AR(8)	5.5621	0.6961
9	2.0149	0.6963	0.3037	AR(9)	6.4955	0.6895
10	2.0735	0.8694	0.1306	AR(10)	7.7541	0.6528
11	1.9181	0.3825	0.6175	AR(11)	9.5434	0.5719
12	1.7182	0.0155	0.9845	AR(12)	12.0859	0.4388

ABOUT NOVANTAS Novantas is the industry leader in analytic advisory and solution services for financial institutions. Our Global Treasury & Risk unit partners with banks to advance their analytic capabilities — bringing to bear our thought leadership, advanced modeling techniques, and extensive experience. The Novantas PPNR Modeling and Forecasting team has worked with more than a third of CCAR banks on PPNR modeling engagements, and is routinely in contact with almost all CCAR banks, many DFAST banks, major international banks in 10+ countries, and U.S. and international regulators.

CONTACT US We welcome your feedback and are happy to continue the conversation about this article or other Treasury and Risk viewpoints. Please reach out to the head of Novantas Global Treasury and Risk, Pete Gilchrist at pgilchrist@novantas.com; or the head of Novantas PPNR Modeling and Forecasting, Jonathan "Wes" West at jwest@novantas.com.