AJAE appendix for "Asset Pricing in Created Markets"

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Panel Unit Root Tests

We use three tests to examine the time series properties of the price series in this study. In all cases, the null hypothesis is that the series are non-stationary of order one. In individual series, it is well-known that the power of unit root tests is low. Panel unit-root tests, however, have been shown in Monte Carlo analyses to have significantly higher power (Banjeree 1999; Levin, Lin, and Chu 2002).

First, we use the test by Levin, Lin, and Chu (LLC, 2002), which was first published as a working paper in 1993 and was formerly known as Levin and Lin's test. This test assumes that each fish stock shares the same AR(1) coefficient, but it does allow for individual fish stock effects, time effects and time trends, and serial correlation in the errors. An advantage of this test over the test proposed by Hadri (2000), for example, is that it is better suited for medium-sized panels similar to ours. We also use the test developed by Im, Pesaran, and Shin (IPS, 2003). This test is similar in spirit to that of Levin and Lin (1993), but the alternative hypothesis allows for heterogeneity in the AR(1) coefficient across stocks. In other words, it permits some (but not all) of the individual series to have unit roots. Finally, we employ the Maddala and Wu (MW, 1999) non-parametric test, which uses the test statistic $-2\sum_{ij=1}^{N}\ln(P_{ij})$, where Π_{ij} is the p-value from the DF or ADF tests for fish each stock *ij*.

The LLC and IPS tests require a balanced panel and our panel is unbalanced because some fish stocks entered the quota management system at different times; for instance, rock lobster entered in 1990–91 (see table 1 for the differences in series length). To address this issue, we conduct the tests for the periods 1990–2001 and 1987–2001, where the former includes most of the shellfish fisheries (but covers a shorter length) and the latter excludes shellfish (but uses a longer panel). Because the MW test does not require a balanced panel, we run the tests for the entire period including all fish stocks regardless of the date at which they entered the system. To be consistent

across the tests, however, we also estimate the test statistic on the same sample as the IPS and LLC methods to compare the results.

For each of these two variables, we undertake the tests at the fish-stock level and also at the species level. For the species level analysis, we use aggregate indices that are a weighted average of the quarterly fish stock prices, where the weights are equal to each fish stock's share of the total species TAC. For the LLC and IPS tests, we include one lag, a constant term, and a common (panel-wide) time trend. The IPS test is done on the cross-sectionally demeaned data (extracting panel-specific time effects). The MW test is similar to the LLC, except that the coefficient on the time trend is allowed to vary across the panel.

We reject the null hypothesis of a panel unit root for the quarterly asset and lease prices at both the fish stock- and species-level aggregations in each of the tests at the 1 percent level. The results are the same regardless of the panel length.

Each of the tests allows serial correlation in the errors, but the LLC and IPS tests are based on the assumption of independence of the errors across fish stocks. Using Monte Carlo simulations, Bornhorst (2003) shows that depending on the nature of the dependence (either short-run correlations or long-run cointegration relationships), the LLC and IPS tests can lead to both type I and type II errors. It is possible that fishing production relationships among stocks (bycatch, for example) might lead to the violation of the error independence assumption. Given the flexibility in the market and especially the role of deemed value payments, it is not clear that these production relationships will be empirically measurable in asset and lease prices during our sample. We did, however, check for possible distortions in our test results by running the same battery of tests after removing the New Zealand Ministry of Fisheries list of Quota Management System species that are caught jointly. We again reject the null hypothesis of a unit root across all tests at the 1 percent level.

An advantage of the MW test is that it is based on the p-values for each individual series in the panel. Running the test therefore also provides the distribution of p-values from the individual series ADF tests, which we find exhibit substantial heterogeneity at both the species and fish stock

levels. For example, using the species-level price indices, we find a median p-value of 0.02 and a mean of 0.11 with a standard deviation of 0.18. The lease prices have a median p-value of 0.01, a mean of 0.079 and standard deviation of 0.156. While understanding the differences in the time series properties across the markets is an interesting question, it falls beyond the scope of the current article.

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