Norwegian Oil Production: a Spatial Analysis

Giacomo Benini, GSEM, giacomo.benini@unige.ch

Overview

The modeling of oil exploration and production is very complicated and requires the analysis of economical, geopolitical and geological realities that are often interdependent (Pesaran, 1990).

In the case of Norway, the displacement of all of its oil rigs on the continental shelf (NCS) is the key to unlock all three dimensions. From an economic prospective the high extraction costs, due to the difficult environmental conditions, make future movements of oil prices more important than for large-scale producers that face simpler extraction conditions. From a political prospective the off-shore location of the resources requires a careful foreign policy with its neighbors. As an example the 2011 agreement with Russia allowed to redefine the maritime boundaries in the Barents Sea and in the Arctic Sea, gaining about 88060 square kilometers of continental shelf to Norway and the opportunity for Russia to develop oil and natural gas deposits that cross over the countries' boundaries using Norwegian know-how. From a geological prospective the segmentation of the NCS into three areas, where the accumulation of hydrocarbons is extremely unevenly displaced shows the presence of irregular clusters of oil rigs.

As a result, any extraction-exploration equilibrium that wants to describe a firm decision plan in the North See must include a *spatial dimension* that captures the uneven displaced of the accumulations which, in turn, tackles the geopolitical and the economic aspects of the problem. However, while there exists an extensive literature on the economy of non-renewable resources that analyses theory-consistent relations between exploratory efforts and produced output, the number of empirical researches that, while doing it, take into account for spatial dependence in the form of cross-section spill-overs are still rare (Hayakawa, Pesaran and Smith, 2014).

The paper, starting from the pioneer work of Hotelling (1931), proposes a new theoretical model that studies the optimal intertemporal trade-offs between production and exploration, while offering a precise micro-foundation of the unobserved heterogeneous spatial patterns. The equilibrium is characterized by: [1] the capability to distinguish between intensive and extensive margins of the cost function of the development and extraction of oil and gas rigs, [2] the need to introduce an autoregressive component as an explanatory variable due to path-dependent nature of the process, [3] the presence of heterogeneous spatial effects, which are the direct result of the omission of geological variables.

The paper is organized as follows. Section 2 presents an economic model that requires a direct modeling of spatial heterogeneity that does not permit an a priori functional form specification. Section 3 discusses an econometric specification able to estimate the equilibrium equation using a local maximum likelihood that differs substantially from the generalized method of moments normally used to estimate semiparametric dynamic panel data models. Section 4 applies the estimation techniques presented in Section 3 to the Norwegian oil production data at a field level. Section 5 presents the conclusions.

Method and Results

The econometric counterpart of the theoretical equilibrium is a (new) semiparametric specification, in the form of a varying coefficient dynamic panel data. The nonparametric part of the model transforms the cross-sectional dependence coefficients into non-random functions of possible hidden (spatial-)paths. The estimation of the structural parameters of the model is done using an unconditional local likelihood function (Hastie and Tibshirani, 1987).

The econometric model is applied to a micro-panel that collects Norwegian oil fields data from 1966 to 2015.

The panel nature of the dataset is able to describe all the salient characteristics of the equilibrium: field-specific heterogeneity, time-series dependency and unobserved cross-sectional correlations; while the semiparametric feature of the econometric specification captures the unobserved spatial patterns without imposing a functional form on the distance between the economic units.

Conclusion

The local likelihood finds significant "unobserved" spatial effect that if ignored would produce biased estimates. The empirical results validates the importance of a direct modeling of the *spatial heterogeneity* that results from the uneven distribution of the cross-section observations within the area of interest.

References

[1] Hayakawa, K., Pesaran, M.H., Smith, L.V., 2014, Transformed Maximum Likelihood Estimation of Short Dynamic Panel Data Models with Interactive Effects. *CESifo Working Paper Series No. 4822*.

[2] Hastie, T., Tibshirani, R., 1987, Local Likelihood Estimation. *Journal of the American Statistical Association*, Vol. 82, No. 398, pp 559-567.

[3] Hotteling, H., 1931, The Economics of Exhaustible Resources. *Journal of Political Economy*, Vol. 39, No. 2, pp 137-175.

[4] Pesaran, M.H., 1990, An Econometric Analysis of Exploration and Extraction of Oil in the U.K. Continental Shelf. *The Economic Journal*, Vol. 100, No. 401, pp 367-390.