A Meta-Frontier Comparison of Hog Market Efficiency in China and the EU

Yali Mu[*1,4], Bernhard Dalheimer[2,3] and Stephan von Cramon-Taubadel[4]

***Corresponding: Yali Mu (ymu@gwdg.de). College of Economics and Management,**

Nanjing Forestry University. LongPan Road 159, XuanWu District, 210018, Nanjing, China.

1. **College of Economics and Management, Nanjing Forestry University**
2. **Department of Agricultural Economics, Kiel University**
3. **Department of Applied Economics, University of Minnesota**
4. **Department of Agricultural Economics and Rural Development, University of Göttingen**

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Motivation

- The efficiency of food markets is key to food security and sustainable food systems (Vermeulen et al., 2012).
- Measuring relative market performance is not straightforward and empirical evidence is scarce (Mu and von Cramon-Taubadel, 2022).
- The drivers of market efficiency has been explored (Svanidze and Götz, 2019; Goodwin and Schroeder, 1991).
- However, the results of market efficiency from different studies are not directly comparable for different regions.
- How efficient can markets be and how can we benchmark and compare market efficiency systematically?
- China and the EU are the world's two largest pork producers and consumers.
- Explore several prominent factors that potentially explain technology difference of market efficiency.

Price Data

- Study period Jul. 2004 - Dec. 2017
- Monthly hog prices from 23 EU member states
- Monthly hog prices from 30 Chinese provinces

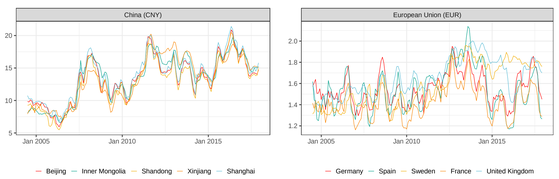

Figure: Selected hog price in China (Yuan/kg) and the EU (Euro/kg)

Empirical Specifications

- First-step: VECMs are used to estimate elasticity of price transmission and adjustment parameters to shocks:

$$\ln p_{i,t} = \beta_{ij,1} \ln p_{j,t} + \beta_{ij,2} T_t + ect_t \tag{1}$$

$$\begin{bmatrix} \Delta \ln p_{i,t} \\ \Delta \ln p_{j,t} \end{bmatrix} = \begin{bmatrix} \varphi_i \\ \varphi_j \end{bmatrix} + \begin{bmatrix} \alpha_i \\ \alpha_j \end{bmatrix} ect_{t-1} + \sum_{k=1}^{l} \begin{bmatrix} \delta_{ik} & \rho_{ik} \\ \delta_{jk} & \rho_{jk} \end{bmatrix} \begin{bmatrix} \Delta \ln p_{i,t-k} \\ \Delta \ln p_{j,t-k} \end{bmatrix} + \sum_{s=1}^{11} \begin{bmatrix} \phi_{1s} \\ \phi_{2s} \end{bmatrix} D_t^s + \begin{bmatrix} \varepsilon_{i,t} \\ \varepsilon_{j,t} \end{bmatrix} \tag{2}$$

- Second-step: The group-specific frontiers are estimated using maximum likelihood:

$$y_{ij} = \gamma_0^g + \gamma_k^g \mathbf{x_{ij}^k} + v_{ij}^g - u_{ij}^g \tag{3}$$

- Third-step: The stochastic metafrontier (SMF) estimated is defined:

$$\hat{y}_{ij} = \gamma_0^{gM} + \gamma_k^M \mathbf{x_{ij}^k} + v_{ij}^{gM} - u_{ij}^{gM} \tag{4}$$

- The calculation of technical efficiency, technology gap ratio and meta technical efficiency:

$$\begin{aligned} TE_{ij}^g &= exp(-u_{ij}^g) \\ TGR_{ij}^g &= exp(-u_{ij}^{gM}) \\ MTE_{ij}^g &= TGR_{ij}^g \times TE_{ij}^g \end{aligned} \tag{5}$$

A Comparable Market Efficiency Benchmark

We propose to benchmark market efficiency of different food systems by using metafrontier analysis. Metafrontiers are useful to model the technological gap and explain its determinants comparably when technology is not identical.

Research Questions

1. What is the maximum attainable market efficiency for China and the EU separately?
2. What are the factors affecting the "technology" of market efficiency?
3. Is there a metafrontier which makes the market efficiency comparable between China and the EU?

China vs. the EU - Hog Markets

Interprovincial markets:

- 30 provinces from a national market
- Free of charge and green path during the shipment
- Various sized farms and small backyards
- Policies designed to stabilize market prices
- A more administrative-based integration (price recommendations)

International markets:

- 23 sovereign countries applying common market regulations
- Stringent animal welfare regulations during pig shipment
- Highly vertically integrated
- Less intervention on pig market (Serra et al., 2006)
- A more arbitrage-based integration

Similar logistical challenges, but different institutional set-ups

Methodology: Roadmap

1. Estimate price transmission elasticity and speed of adjustments of markets in both China and the EU separately (Vector Error Correction Model).
2. Specify stochastic frontiers to benchmark regional market efficiency for China and the EU individually.
3. Combine the individual market efficiency frontiers to specify a metafrontier that enables to quantify the market technology gap ratios for the two regions.
4. Compare technical efficiency and technology gap between hog markets in China and the EU.
5. Draw related policy to improve regional food market integration and efficiency China and the EU.

Estimated Market Efficiency Frontiers

	EU	China	Meta
Intercept	0.941 (55.89)	0.956 (108.76)	0.961 (719.18)
Distance	−0.025 (−2.92)	−0.009 (−2.81)	−0.009 (−52.58)
Currency	0.002 (0.12)		−0.0014 (−1.03)
Land	−0.002 (−0.22)	0.003 (0.61)	0.002 (12.42)
Carcass	0.004 (0.64)	−0.001 (−0.40)	−0.001 (−8.51)
Mid-farm	−0.003 (−0.73)	0.012 (4.17)	0.011 (78.47)
Mean TE	0.886	0.939	0.983
Log likeli	220.870	678.151	2690.421
Obs	253	435	688

Table: Stochastic frontier models for $\hat{\beta}_{ij,1}$

	EU	China	Meta
Intercept	0.274 (10.42)	0.785 (12.53)	0.370 (91.60)
Distance	−0.001 (−0.16)	−0.027 (−13.75)	−0.028 (−29.63)
Currency	0.023 (2.54)		0.416 (111.34)
Land	0.008 (1.21)	−0.065 (−52.98)	−0.062 (−80.09)
Carcass	−0.001 (−0.25)	−0.002 (−2.72)	−0.002 (−4.11)
Mid-farm	−0.020 (−4.59)	0.007 (9.63)	0.008 (14.28)
Mean TE	0.953	0.734	0.895
Log likeli	252.113	303.051	999.373
Obs	253	435	688

Table: Stohastic frontier models for $\hat{\alpha}_{ij}$

Results

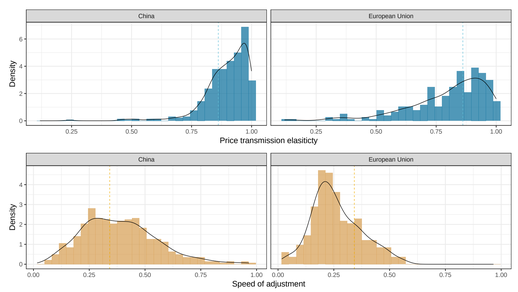

Figure: Distribution of estimated $\hat{\beta}_{ij,1}$ and $\hat{\alpha}_{ij}$ for China and the EU

		China			EU		
	Statistic	TE	TGR	MTE	TE	TGR	MTE
$\hat{\beta}_{ij,1}$	Mean	0.94	0.99	0.94	0.89	0.96	0.85
	SD	0.06	0.00	0.06	0.12	0.02	0.11
	Min	0.62	0.99	0.62	0.43	0.91	0.43
	Max	0.99	1.00	0.99	1.00	0.99	0.98
$\hat{\alpha}_{ij}$	Mean	0.73	0.99	0.73	0.95	0.72	0.69
	SD	0.09	0.01	0.09	0.03	0.30	0.28
	Min	0.54	0.99	0.54	0.75	0.00	0.00
	Max	0.99	0.99	0.99	0.99	0.99	0.98

Table: Technical efficiency, technology gap ratio & meta technical efficiency

Key Results

Overall EU hog markets are less integrated than Chinese markets.
Long-term market integration is more homogeneous in China than in the EU while short-term adjustments are less heterogeneous in EU hog markets.
The distance effect on international markets in the EU doubles the effect on interprovincial markets in China.

Conclusions

- Chinese hog markets are closer to the maximum attainable price transmission elasticities (frontier) than its EU counterparts in the long-run.
- In the short-run the EU markets adjust slower with denser speeds of adjustment on average whenever there is a shock to make the markets under disequilibrium.
- The difference may be due to more pronounced geographic effects of EU member states on hog market integration while in China infrastructure plays a relatively stronger role.
- Higher transport costs and more stringent animal welfare-based restrictions on transporting live hogs impedes the market eiciency in the EU.
- In the EU a trade-off between market integration and animal welfare could persist.

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Contact Information

Mu,Yali (穆亚丽)
ymu@gwdg.de
College of Economics and Management,
Nanjing Forestry University.
LongPan Road 159, XuanWu District,
210018, Nanjing, China.

Twitter: twitter.com/muyali1992