Hysteresis Nonlinearities in Exports: Evidence from European Wine Exports to the US

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FernUniversitaet in Hagen

11th Annual AAWE Conference 2017
AAWE Working Paper No. 215
Outline

1. Hysteresis
2. Play method
3. Preisach method
4. Results
5. Interpretation
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1. Hysteresis
2. Play method
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Hysteresis, what is that?

- The idea of hysteresis originates from physics (magnetics)
- The term comes from ancient Greek and means "lagging behind"
- Found in physics, engineering, biology or economics (trade, labor market)

Characteristics:
- Non-linearity
- Path-dependency
Hysteresis, what is that?

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- Characteristics:
  - Non-linearity
  - Path-dependency
Non-ideal relay

Number of exporting firms

0
1

exit threshold $\beta$
entry threshold $\alpha$

Exchange rate in indirect quotation
Each exporter is characterized by his entry and exit thresholds
- entry threshold $\neq$ exit threshold
- sunk costs are the reason for hysteresis
- aggregate heterogeneous exporters $\Rightarrow$ hysteresis loop
Number of exporting firms

Exchange rate in indirect quotation

non-ideal relay 1
Number of exporting firms vs. Exchange rate in indirect quotation.
Number of exporting firms

Exchange rate in indirect quotation

Hysteresis

Play method

Preisach method

Results

Interpretation

Appendix

Number of exporting firms

Exchange rate in indirect quotation

curved hysteresis loop

play hysteresis loop

non-ideal relay 1

non-ideal relay 2

non-ideal relay 3
Why analysing the wine market?

- As home consumption decreases, exports become more important
- It takes effort to export (relationships)
- There are many regulations on the US market
- It needs time to change the kind of grapes or plant new wine
  ⇒ sunk costs
Why analysing the wine market?

- As home consumption decreases, exports become more important

4. Volume of national wine consumption, 1985-89 and 2005-09 (ML per year)

Why analysing the wine market?

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  - There are many regulations on the US market
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Idea of Belke and Göcke: linearization of the hyst. loop
Idea of Belke and Göcke: linearization of the hyst. loop
Practical derivation: move element II by controlling element I:
Play Algorithm

![Graph showing play hysteresis loop with labels for exports and exchange rate in indirect quotation.]

- Play hysteresis loop
- Play
- Exchange rate in indirect quotation
Play Algorithm

Procedure:

- Build new variable which captures only the large changes
- Estimate an OLS-Model with and without this additional variable

\[
Wine_t = c + \alpha_1 \cdot RER_t + \delta_1 \cdot GDP_{US_{t-1}} + \phi_1 \cdot Trend + seas.Dummies
\]

\[
Wine_t = c + \alpha_2 \cdot RER_t + \beta \cdot s_t + \delta_2 \cdot GDP_{US_{t-1}} + \phi_2 \cdot Trend + seas.Dummies
\]

- Compare both models
Procedure:

- Build new variable which captures only the large changes

Estimate an OLS Model with and without this additional variable.
Procedure:

- Build new variable which captures only the large changes
- Estimate an OLS-Model with and without this additional variable

\[
Wine_t = c + \alpha_1 \cdot RER_t + \delta_1 \cdot GDP\_US_{t-1} + \phi_1 \cdot Trend \\
+ \text{seas.Dummies}
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\[
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\]

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Outline

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Preisach method

- **Origin** Preisach (1935), magnetics
- Implementation by Piscitelli et. al (2000)
- **Idea**: basis non-ideal relay, exact aggregation procedure via Preisach triangle
- **Result**: Preisach variable, similar to spurt
Preisach method

- Origin Preisach (1935), magnetics

(Mitteilung aus dem Zentrallaboratorium des Wernerwerkes der Siemens & Halske A.-G.)

Über die magnetische Nachwirkung.

Von F. Preisach in Berlin-Siemensstadt.

Mit 15 Abbildungen. (Eingegangen am 15. Februar 1935.)


I. Einleitung.

Es ist schon häufig die Frage gestellt worden, ob bei ferromagnetischen Stoffen die Magnetisierung der Feldstärke trägheitslos folgt, oder ob zur Entstehung einer bestimmten Magnetisierung eine endliche Zeit notwendig sei. Zur Beantwortung der Frage sind schon zahlreiche verschiedenartige Versuche angestellt worden, ohne endgültige Lösung des Problems.

Bei einer Art von Untersuchungen wird die nach plötzlichem Einschalten eines Gleichfeldes sich einstellende Magnetisierung zeitlich registriert („Schaltversuch“). Die anderen wichtigen Untersuchungsmethoden bestehen...
Preisach method

- Origin Preisach (1935), magnetics
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Non-ideal relay

- Number of exporting firms
- Exit threshold $\beta$
- Entry threshold $\alpha$
- Exchange rate in indirect quotation

Non-ideal relay graph:

- Y-axis: Number of exporting firms (0 to 1)
- X-axis: Exchange rate in indirect quotation

Diagram shows a step function with thresholds $\beta$ and $\alpha$.
Aggregation via Preisach triangle

\[
\alpha = \beta
\]

\[
S^+ + S^- + S^+ + S^+ - S^- - S^- - S^+ \leq \alpha_{\text{max}}
\]
Comparison of exchange rate, spurt and Preisach variable
Preisach procedure

- Estimate three OLS-Models: without PV, in addition with PV, and with PV but without RER

\[
Wine_t = c + \alpha_1 \cdot RER_t + \delta_1 \cdot GDP_{US_{t-1}} + \phi_1 \cdot Trend + \text{seas.Dummies}
\]

\[
Wine_t = c + \alpha_2 \cdot RER_t + \beta \cdot PV_t + \delta_2 \cdot GDP_{US_{t-1}} + \phi_2 \cdot Trend + \text{seas.Dummies}
\]

\[
Wine_t = c + \beta \cdot PV_t + \delta_2 \cdot GDP_{US_{t-1}} + \phi_2 \cdot Trend + \text{seas.Dummies}
\]

- Wine ∈ \{Values, Quantities, Prices(UnitValues)\}
- Compare the models with the PV with the model without
Preisach procedure

- Estimate three OLS-Models: without PV, in addition with PV, and with PV but without RER

\[
Wine_t = c + \alpha_1 \cdot RER_t + \delta_1 \cdot GDP_{US_{t-1}} + \phi_1 \cdot Trend \\
+ \text{seas.Dummies}
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\[
Wine_t = c + \alpha_2 \cdot RER_t + \beta \cdot PV_t + \delta_2 \cdot GDP_{US_{t-1}} + \phi_2 \cdot Trend \\
+ \text{seas.Dummies}
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\[
Wine_t = c + \beta \cdot PV_t + \delta_2 \cdot GDP_{US_{t-1}} + \phi_2 \cdot Trend \\
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\]

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- Compare the models with the PV with the model without
Preisach procedure

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\[ Wine_t = c + \alpha_1 \cdot RER_t + \delta_1 \cdot GDP_{US t-1} + \phi_1 \cdot Trend + \text{seas.Dummies} \]
\[ Wine_t = c + \alpha_2 \cdot RER_t + \beta \cdot PV_t + \delta_2 \cdot GDP_{US t-1} + \phi_2 \cdot Trend + \text{seas.Dummies} \]
\[ Wine_t = c + \beta \cdot PV_t + \delta_2 \cdot GDP_{US t-1} + \phi_2 \cdot Trend + \text{seas.Dummies} \]

- \( Wine \in \{ \text{Values}, \text{Quantities}, \text{Prices(UnitValues)} \} \)
- Compare the models with the PV with the model without
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## Comparison of models

<table>
<thead>
<tr>
<th></th>
<th>Spurt</th>
<th>Preisach (add.)</th>
<th>Preisach (repl.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Values</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Spain</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>France</td>
<td>H</td>
<td>-</td>
<td>(-)</td>
</tr>
<tr>
<td><strong>Quantities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>H</td>
<td>-</td>
<td>(-)</td>
</tr>
<tr>
<td>Spain</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>France</td>
<td>plus</td>
<td>plus</td>
<td>(-)</td>
</tr>
<tr>
<td><strong>Prices</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Spain</td>
<td>plus</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>France</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>
- Spurt and Preisach replacement method concur with one another
- Preisach addition method is most conservative, can be used to testify and confirm the other methods
## Summary of hysteresis outcomes

<table>
<thead>
<tr>
<th>Values</th>
<th>Quantities</th>
<th>Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>H</td>
<td>H(sp)</td>
</tr>
<tr>
<td>Spain</td>
<td>H</td>
<td>-</td>
</tr>
<tr>
<td>France</td>
<td>H(sp)</td>
<td>plus</td>
</tr>
</tbody>
</table>

H indicates a high value, H(sp) indicates a high value with a specific qualifier, and - indicates no value.
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Summary

- Hysteresis was found and there are different sources for it
- Hysteresis more likely to be found in values $\iff$ values aggregate non-linearities of both hyst. sources
- Hysteresis rather found in prices than in quantities, either the quantities react immediately or not at all (quality substitution in Italy and Spain) and/or pricing to market (Fertoe, Balogh(2016))
- Italy: hyst. in prices results in hyst. in values
- France: hyst. in prices and hyst. in quantities neutralize each other
- Spain: no hyst. in prices and quantities but in values
Thank you for your attention and your comments!
K. Anderson, S. Nelge  
University of Adelaide Press, 2011.

A. K. Dixit, R. S. Pindyck.  
*Investment under Uncertainty.*  

I. Mayergoyz.  
*Mathematical Models of Hysteresis and their Applications.*  

M. Krasnoselskii, A. Pokrovskii  
*Systems with Hysteresis.*  
A. Belke, M. Goecke
Exchange rate uncertainty and employment: An Algorithm describing "Play".

A. Belke, M. Goecke, M. Guenther
Exchange rate bands of inaction and play-hysteresis in German exports - sectoral evidence for some OECD destinations.

M. Goecke, L. M. Werner
Play-hysteresis in supply or in demand as part of a market model.
Literatur III

- L. Piscitelli, R. Cross, M. Grinfeld, H. Lamba
  A Test for Strong Hysteresis.

- M. Grinfeld, R. Cross, H. Lamba
  Hysteresis and economics - taking the economic past into account.

- A. Hallett, L. Piscitelli
  Testing for hysteresis against nonlinear alternatives.

- D. de Prince, S. Kannebley Junior
  Strong hysteresis in Brazilian imports: a panel cointegration approach.
Literatur IV

B. Beliveau, M. Rouse
Prohibition and repeal: A short history of the wine industry’s regulation in the United States.

I. Fertoe, J.M. Balogh
Are the major European wine exporters able to price discriminate across their EU extra wine export destinations?.
*Institute of Economics, Centre for Economic and Regional Studies, Hungarian Academy of Sciences, 2016.*
## Outcomes of the Preisach replacement method

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Italy</th>
<th>Spain</th>
<th>France</th>
</tr>
</thead>
<tbody>
<tr>
<td>RER</td>
<td>$-66,031,297.0^{***}$</td>
<td>$-4,587,862.0^*$</td>
<td>$-146,680,756.0^{***}$</td>
</tr>
<tr>
<td></td>
<td>(12, 943, 883.0)</td>
<td>(2, 566, 260.0)</td>
<td>(19, 631, 886.0)</td>
</tr>
<tr>
<td>GDP</td>
<td>$118.1^{***}$</td>
<td>$11.3^{***}$</td>
<td>$172.8^{***}$</td>
</tr>
<tr>
<td></td>
<td>(18.9)</td>
<td>(4.2)</td>
<td>(34.4)</td>
</tr>
<tr>
<td>Trend</td>
<td>$145,930.4$</td>
<td>$278,021.6^{***}$</td>
<td>$-1,910,857.0^{***}$</td>
</tr>
<tr>
<td></td>
<td>(337, 574.1)</td>
<td>(75, 936.5)</td>
<td>(594, 417.7)</td>
</tr>
<tr>
<td>d1</td>
<td>$-26,585,933.0^{***}$</td>
<td>$-9,416,873.0^{***}$</td>
<td>$-43,704,146.0^{***}$</td>
</tr>
<tr>
<td></td>
<td>(4, 667, 843.0)</td>
<td>(1, 037, 079.0)</td>
<td>(8, 271, 254.0)</td>
</tr>
<tr>
<td>d2</td>
<td>$-2,557,228.0$</td>
<td>$-3,246,850.0^{***}$</td>
<td>$-20,904,312.0^{**}$</td>
</tr>
<tr>
<td></td>
<td>(4, 676, 287.0)</td>
<td>(1, 038, 066.0)</td>
<td>(8, 281, 003.0)</td>
</tr>
<tr>
<td>d3</td>
<td>$-5,555,623.0$</td>
<td>$29,219.8$</td>
<td>$10,244,066.0$</td>
</tr>
<tr>
<td></td>
<td>(4, 672, 343.0)</td>
<td>(1, 038, 204.0)</td>
<td>(8, 278, 860.0)</td>
</tr>
<tr>
<td>Constant</td>
<td>$-109,691,355.0^{**}$</td>
<td>$-2,472,770.0$</td>
<td>$-32,970,978.0$</td>
</tr>
<tr>
<td></td>
<td>(49, 352, 571.0)</td>
<td>(10, 847, 929.0)</td>
<td>(90, 757, 922.0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observations</th>
<th>75</th>
<th>75</th>
<th>75</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>0.914</td>
<td>0.925</td>
<td>0.750</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.907</td>
<td>0.919</td>
<td>0.728</td>
</tr>
<tr>
<td>Residual Std. Error (df = 68)</td>
<td>14, 185, 828.0</td>
<td>3, 150, 905.0</td>
<td>25, 137, 882.0</td>
</tr>
</tbody>
</table>
### Results

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Italy</th>
<th>Spain</th>
<th>France</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV</td>
<td>$-221,115,043.0^{***}$</td>
<td>$-15,842,735.0^{**}$</td>
<td>$-440,265,425.0^{***}$</td>
</tr>
<tr>
<td></td>
<td>$(28,329,942.0)$</td>
<td>$(6,697,195.0)$</td>
<td>$(63,410,536.0)$</td>
</tr>
<tr>
<td>GDP</td>
<td>$47.9^{**}$</td>
<td>$5.6$</td>
<td>$81.7^{*}$</td>
</tr>
<tr>
<td></td>
<td>$(19.7)$</td>
<td>$(5.2)$</td>
<td>$(41.9)$</td>
</tr>
<tr>
<td>Trend</td>
<td>$1,207,405.0^{***}$</td>
<td>$378,542.4^{***}$</td>
<td>$-381,938.8$</td>
</tr>
<tr>
<td></td>
<td>$(345,211.4)$</td>
<td>$(94,706.2)$</td>
<td>$(727,823.1)$</td>
</tr>
<tr>
<td>d1</td>
<td>$-25,866,726.0^{***}$</td>
<td>$-9,364,930.0^{***}$</td>
<td>$-42,448,684.0^{***}$</td>
</tr>
<tr>
<td></td>
<td>$(3,986,501.0)$</td>
<td>$(1,019,691.0)$</td>
<td>$(8,538,639.0)$</td>
</tr>
<tr>
<td>d2</td>
<td>$-2,045,945.0$</td>
<td>$-3,231,552.0^{***}$</td>
<td>$-19,867,219.0^{**}$</td>
</tr>
<tr>
<td></td>
<td>$(3,989,710.0)$</td>
<td>$(1,020,598.0)$</td>
<td>$(8,544,790.0)$</td>
</tr>
<tr>
<td>d3</td>
<td>$-5,173,762.0$</td>
<td>$52,290.0$</td>
<td>$11,337,916.0$</td>
</tr>
<tr>
<td></td>
<td>$(3,987,434.0)$</td>
<td>$(1,020,263.0)$</td>
<td>$(8,541,323.0)$</td>
</tr>
<tr>
<td>Constant</td>
<td>$2,934,969.0$</td>
<td>$7,397,190.0$</td>
<td>$41,444,417.0$</td>
</tr>
<tr>
<td></td>
<td>$(47,592,850.0)$</td>
<td>$(12,381,531.0)$</td>
<td>$(101,309,325.0)$</td>
</tr>
<tr>
<td>Observations</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>R$^2$</td>
<td>0.937</td>
<td>0.928</td>
<td>0.734</td>
</tr>
<tr>
<td>Adjusted R$^2$</td>
<td>0.932</td>
<td>0.921</td>
<td>0.710</td>
</tr>
<tr>
<td>Residual Std. Error</td>
<td>$12,114,818.0$</td>
<td>$3,099,106.0$</td>
<td>$25,948,725.0$</td>
</tr>
<tr>
<td>F statistic (df = 6; 68)</td>
<td>169.8$^{***}$</td>
<td>145.2$^{***}$</td>
<td>31.2$^{***}$</td>
</tr>
</tbody>
</table>

**Note:**

* p < 0.1; ** p < 0.05; *** p < 0.01
Summary

- For Italy and Spain hysteresis was found for export values for the period 1995-2013
- Not only the absolute exchange rate change but also the path and therefore past values matter
- Small up and down changes do not matter but large ones or many small ones in the same direction
- Hysteresis influences slow down adjustment processes but they do not prevent them
Summary

- No hysteresis was found for France, why?
- Other export strategy? ⇒ export of high-priced wine
- Hysteresis was found in values but there are different sources for it
- Values aggregate non-linearities of possible hyst. in prices and possible hyst. in quantities
- Next step of research!
Computation of the spurt variable

Start in minimum, initial values

- $s_0 := x_0$, where $x$ is the exchange rate
- $p > 0$, width of play area

\[ s_{t+1} := \begin{cases} 
  s_t & \text{if } 0 \leq (x_{t+1} - s_t) \leq p \\
  x_{t+1} + p & \text{if } (x_{t+1} - s_t) > p \\
  x_{t+1} & \text{if } (x_{t+1} - s_t) < 0
\end{cases} \]