Aggregation of higher-level price indices

Workshop on use and integration of new data sources for the CPI

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Overview

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2. Lowe and Young price indices
3. Superlative price indices
4. Demand price elasticities
5. Conclusion
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Calculation of higher-level price index

CPI calculated in two steps

1. Elementary aggregate price indices

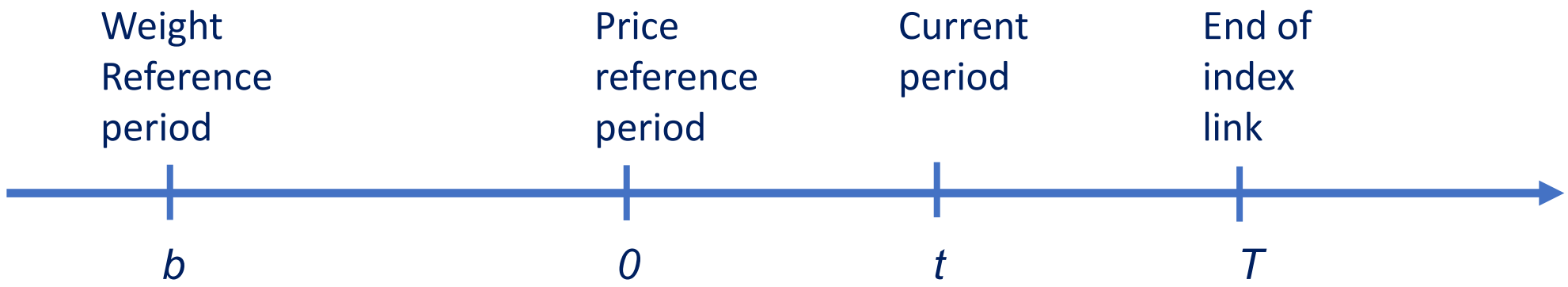
Aggregation of individual price observations into elementary price indices

2. Higher-level price indices

Calculated as the expenditure weighted average of elementary price indices

Calculation of higher-level price index

Reference periods



Usually, expenditure weights are not available for period *0 when the index starts*

Weights will refer to a year (or several years) while prices are monthly (or quarterly)

Lowe and Young price indices

Calculate a Lowe or a Young index

$$P_{0:t}^{Lowe} = \sum w_{b(0)}^{i} P_{0:t}^{i}$$

No substitution, quantities kept constant from *b* to *T*

$$P_{0:t}^{Young} = \sum w_{b}^{i} P_{0:t}^{i}$$

Substitution from *b* to *0*, no substitution from *0* to *T*

$$w_b^i = \frac{p_b^i q_b^i}{\sum p_b^i q_b^i} \qquad w_{b(0)}^i = \frac{w_b^i P_{b:0}^i}{\sum w_b^i P_{b:0}^i}$$

Lowe and Young price indices

Alternative geometric higher-level price indices

$$P_{0:t}^{GeoYoung} = \prod P_{0:t}^{i}{}^{w_b^i}$$

$$P_{0:t}^{GeoLowe} = \prod P_{0:t}^{i}{}^{w_{b(0)}^i}$$

Why chose a geometric mean?

- Reduce upward bias compared to Lowe/Young
- Consistency in aggregation with Jevons elementary indices
- GeoYoung more consistent than Young regarding substitution

Lowe and Young price indices

Lowe and Young demand price elasticities (σ)

	Period b to 0	Period 0 to T
Lowe	σ = 0	σ = 0
Young	σ = 1	σ = 0
GeoLowe	σ = 0	σ = 1
GeoYoung	σ = 1	σ = 1

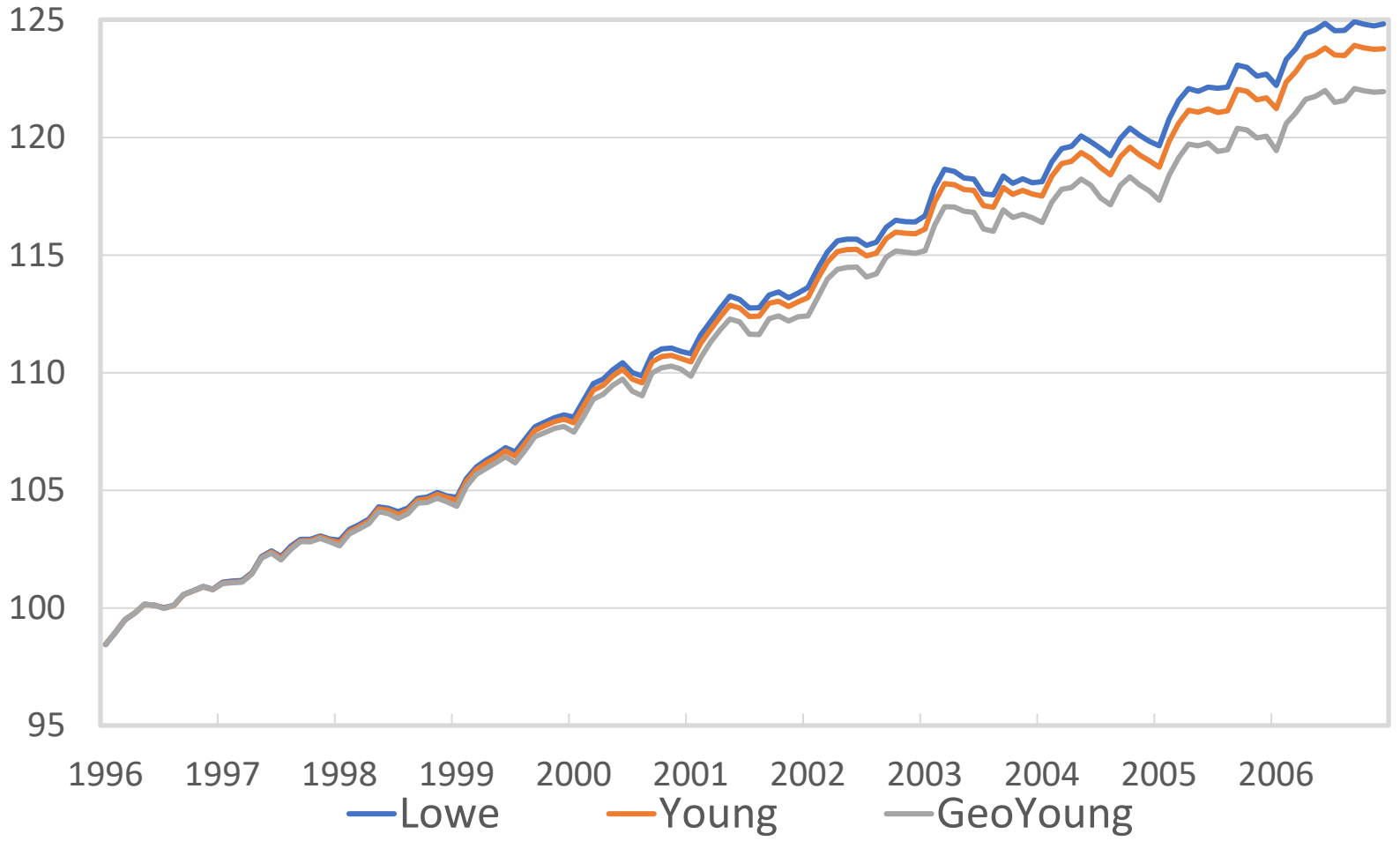
Young > GeoYoung and Lowe > GeoLowe

Lowe and Young price indices

Let’s look at some figures ….

Lowe and Young price indices

Lowe and Young indices 1996-2006 (Denmark, 1996=100)

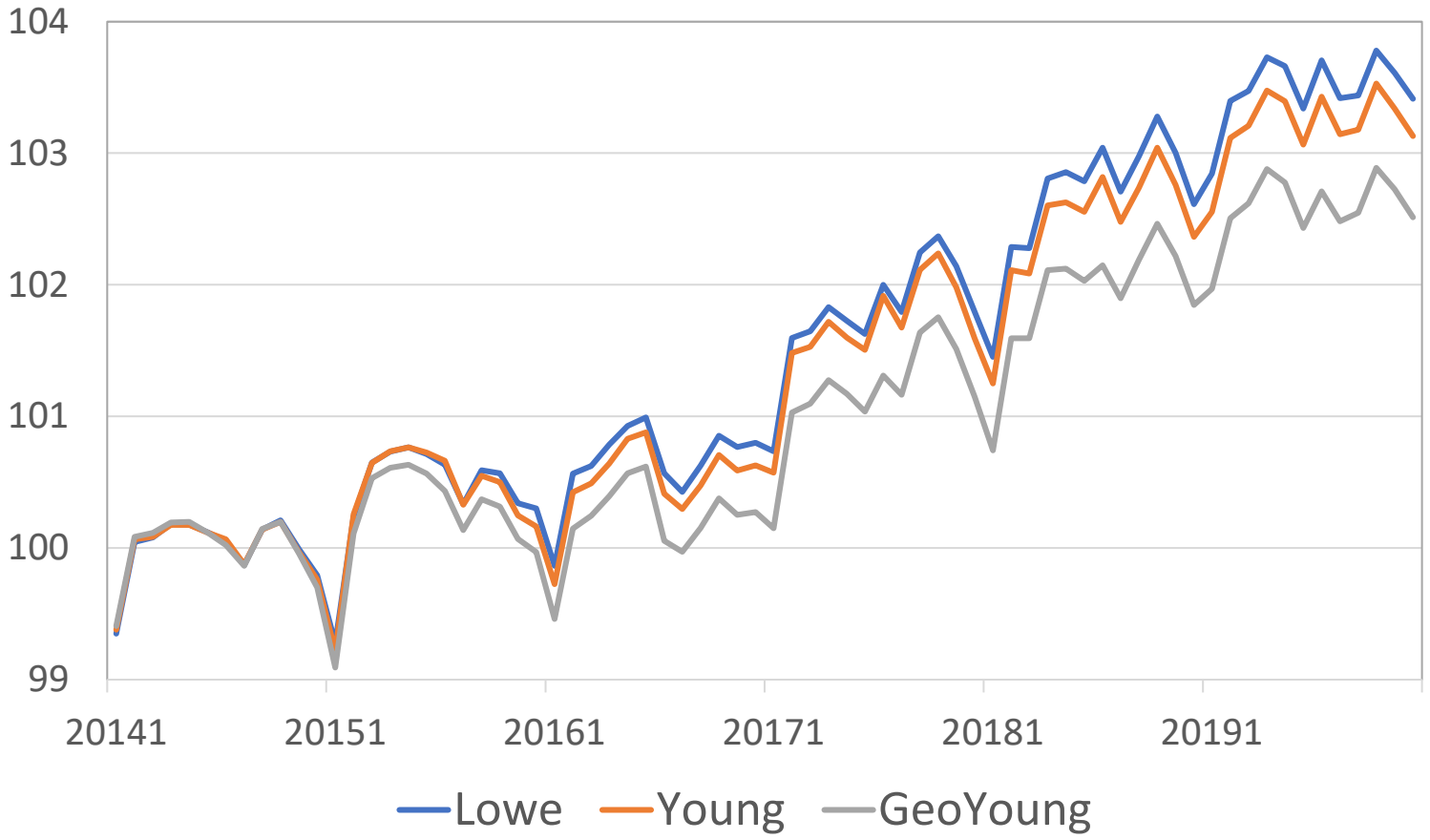


Annual average % change:

Lowe: 2,20
Young: 2,11
GeoYoung: 1,96

Lowe and Young price indices

Lowe and Young indices 2014-2019 (Denmark, 2014=100)



Annual average % change:

Lowe: 0,69
Young: 0,63
GeoYoung: 0,51

Superlative price indices

How to evaluate Lowe and Young indices?

Compare with superlative price indices, Fisher, Walsh and Törnqvist

"Fisher, Walsh and Törnqvist price indices approximate each other very closely using "normal" time series data. This is a very convenient result since these three index number formulae repeatedly show up as being "best" in all the approaches to index number theory. Hence, this approximation result implies that it normally will not matter which of these indices is chosen as the preferred target index for a consumer price index." (2004 *CPI Manual, p*. 313)

Superlative price indices

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$$P_{0:t}^{F} = \left[\left(\sum w_0^i P_{0:t}^i\right)\left(\sum w_t^i \left(P_{0:t}^i\right)^{-1}\right)^{-1}\right]^{\frac{1}{2}}$$

$$P_{0:t}^{W} = \sum w_W^i \cdot P_{0:t}^i, \qquad w_W^i = \frac{\sqrt{\left(w_0^i \cdot w_t^i\right)/P_{0:t}^i}}{\sum \sqrt{\left(w_0^i \cdot w_t^i\right)/P_{0:t}^i}}$$

$$P_{0:t}^{T} = \prod \left(P_{0:t}^i\right)^{\frac{\left(w_0^i + w_t^i\right)}{2}}$$

- Require weights from both periods compared
- When weights become available it is possible retrospectively to calculate estimates of superlative CPIs

Superlative price indices

1996-2003 (Denmark) (annual rate of change in %)

	1997	1998	1999	2000	2001	2002	2003	Average
Walsh	2.05	1.77	2.44	2.76	2.34	2.52	2.06	2.28
Fisher	2.08	1.75	2.37	2.79	2.31	2.54	2.01	2.27
Törnqvist	2.08	1.76	2.40	2.81	2.35	2.52	2.00	2.27

2012-2018 (Denmark) (annual rate of change in %)

	2013	2014	2015	2016	2017	2018	Average
Fisher	0,67	0,47	0,18	0,10	0,97	0,64	0,50
Walsh	0,67	0,47	0,18	0,10	0,97	0,64	0,50
Törnqvist	0,66	0,47	0,18	0,10	0,97	0,64	0,50

Superlative price indices and Lowe and Young

1996-2003 (Denmark) (annual changes in %)

	1997	1998	1999	2000	2001	2002	2003	Average
Lowe	2.18	1.9	2.56	3.03	2.43	2.52	2.14	2.39
Young	2.13	1.86	2.51	2.91	2.37	2.45	2.09	2.33
GeoYoung	2.08	1.77	2.4	2.74	2.2	2.31	1.94	2.21
Walsh	2.05	1.77	2.44	2.76	2.34	2.52	2.06	2.28

2014-2018 (Denmark)

	Annual chained indices (2014=100)				Av. annual % change
	2015	2016	2017	2018	2014-18
Lowe	100,43	100,65	101,79	102,67	0,66
Young	100,40	100,51	101,66	102,45	0,61
GeoYoung	100,24	100,21	101,19	101,91	0,47
Walsh	100,18	100,28	101,26	101,90	0,47

Superlative price indices

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	Average annual rate of change (%)				Differences in annual rate of change (% point)			
	Lowe	Young	Geometric Young	Superlative index	Lowe – Young	Lowe – superlative index	Young – superlative index	GeoYoung – superlative index
Denmark 2014-2018	0,66	0,61	0,47	0,47	0,05	0,19	0,14	0,00
Denmark 1996-2003	2,39	2,33	2,21	2,28	0,06	0,11	0,05	-0.07
Canada 1996-2005	2,08	1,99	1,80	1,86	0,09	0,21	0,12	-0.06
USA 2001-2007	2,50	2,42	2,12	2,24	0,08	0,26	0,18	-0.12
USA 2002-2010	2,49	2,35	2,15	2,31	0,14	0,18	0,04	-0.16
New Zeal. 2006-2008	3,08	2,76	2,39	2,83	0,32	0,25	-0,07	-0.44

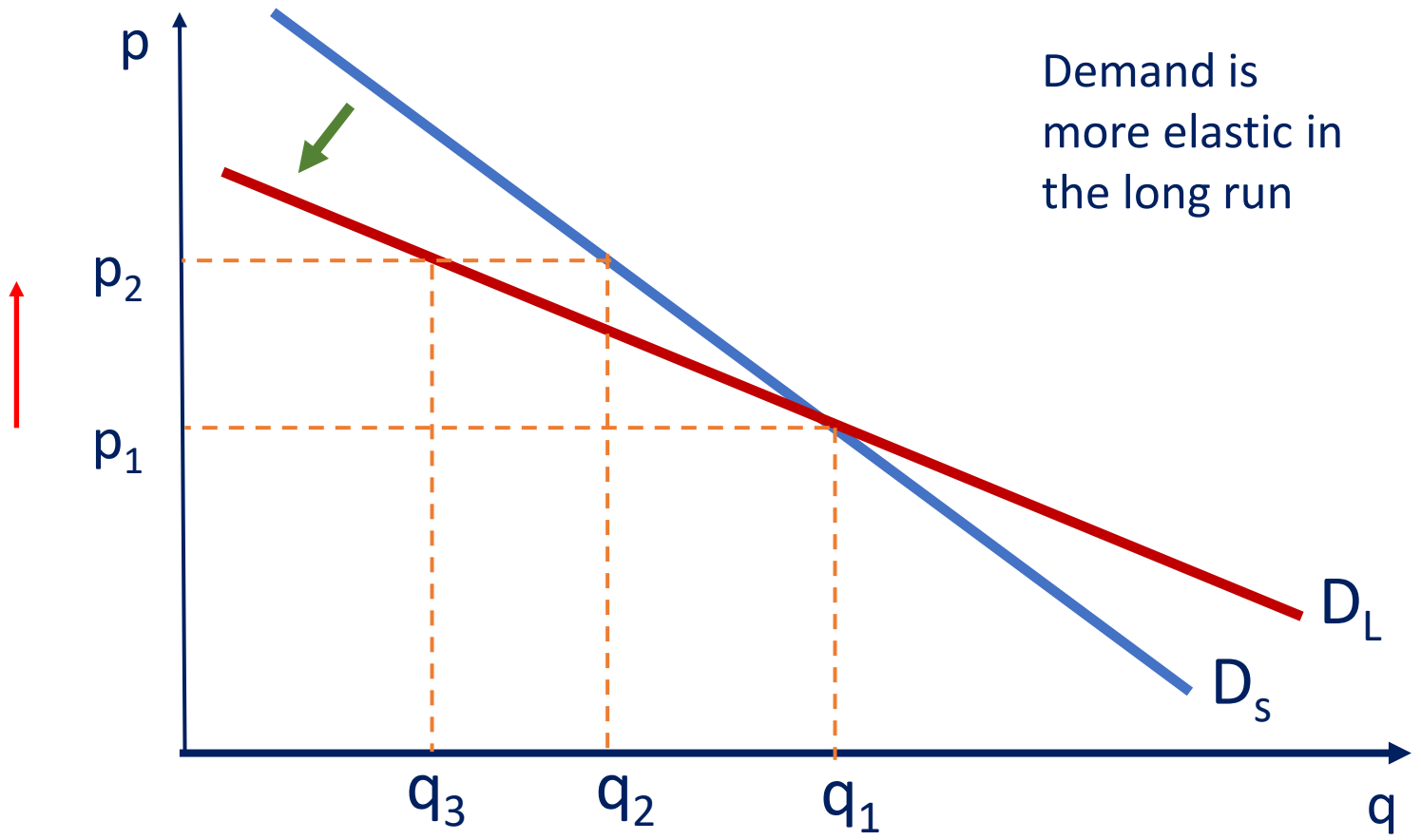
Superlative price indices

Some general conclusions:

1) Lowe exceeds Young – price-updating increases the rate of change of the CPI.
2) Arithmetic Young exceeds geometric Young
3) Lowe and Young are biased upward compared to a superlative price index, Lowe more than Young (except New Zealand 2006-2008)
4) Geometric Young is biased downward compared to a superlative index (except Denmark 2014-2018)

It is all about consumer behaviour, substitution and price elasticities!

Demand price elasticities



Demand price elasticities, Norway

	Short-term	Medium-term	Long-term
Food	-0,12	-0,26	-0,52
Beverages	-0,93	-0,94	-0,94
Tobacco	-0,67	-0,70	-0,77
Electricity	-0,04	-0,13	-0,31
Fuel for housing	-0,37	-0,58	-0,60
Fuel for transport	-0,51	-0,60	-0,89
Other non-durable goods	-0,86	-0,96	-1,18
Clothing and footwear	-0,56	-0,68	-0,87
Purchase of own vehicle	-0,80	-1,51	-1,59
Other durable goods	-0,28	-0,73	-1,05
Other services	-0,35	-0,49	-0,75
Transport services	-0,92	-0,96	-1,05
Consumption abroad	-0,78	-0,97	-1,43
Weighted average	**-0,52**	**-0,69**	**-0,92**

Demand price elasticities, Denmark

	Price elasticities	
	Short-term	Long-term
Food	-0,09	-0,19
Beverages and tobacco	-0,09	-0,50
Other non-durable goods	-0,40	-0,81
Fuel	-0,20	-0,70
Transport	-0,16	-0,94
Durable goods	-0,36	-0,93
Services	-0,21	-0,91
Tourist expenditures	-0,26	-1,27
Weighted average	**-0,22**	**-0,79**

Issues in geometric aggregation of higher-level CPIs

- More difficult to interpret as a fixed basket index
- May overestimate substitution - and therefore underestimate inflation
- Only used by few countries
- Likely not used for other price indices (PPIs etc.)
- Must be explained to user
- Loss of easy additivity
- More difficult to calculate contribution of sub-indices to overall CPI change

Conclusion

- Which index to prefer depends on the target and the purpose of the CPI
- Lowe keeps quantities constant, no substitution
- Young assumes some substitution (from *b* to *0*)
- Geometric Young assumes substitution (from *b* to *T*)
- In all cases, reduce the time lag in the weighting data (from b to 0)
- If moving to Geometric Young, consider the purpose of the CPI and user needs
- Compile GeoYoung and compare with Young, Lowe or superlative indices
- Build data base to perform aggregation analyses

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