

# What is the "duration" of Swiss direct real estate?

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# Why real estate?

Including real estate in a portfolio has proven to bring diversification benefits for both homeowners [Mahieu, Van Bussel 1996] and institutional investors [Hoesli, Hamelink 1997].

- ▶ These assets tend to have relatively stable cash flows over time.
- ▶ Is a good hedge for both expected and unexpected inflation.
- ▶ Low volatility in capital values (as compared to equity) and low correlation to financial assets.

## Therefore:

- ▶ Direct real estate investments are present in many institutional portfolios (ALM); on average 19% of their portfolio is in property [Anderson et al., 1993].
- ▶ Duration is one important tool to manage any ALM mismatch.

**But:** *Can one use bond duration with real estate directly?*

What is the "duration" of Swiss direct real estate?

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# The Macaulay duration

What is the  
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- ▶ Duration represents a measure of the maturity profile of the promised cash flows of an income security with a *predefined* cash-flow stream. The Macaulay's duration is defined as:

$$D = \frac{\sum_{t=1}^N \frac{t \cdot C(t)}{(1+r)^t}}{P_0}$$

- ▶ Duration also represents the elasticity of an asset price with respect to the discount factor. As an elasticity measure, duration can be written as:

$$D = \frac{-dP}{dr} * \frac{(1+r)}{P}$$

- ▶ For bonds that have embedded options, such as puttable and callable bonds, Macauley duration and modified duration will not correctly approximate the price move for a change in yield.

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# Macaulay duration and real estate?

What is the  
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Several features of real estate argue against using the traditional measure of duration:

- ▶ No fixed cash-flows, no fixed maturity, possibility to "upgrade" the asset through investment.
- ▶ The *high fragmentation of the market* and the *informational asymmetry* ensure that the "face value" is not readily available to all market participants.
- ▶ The *low liquidity* of the market and the *high transaction costs* hinder the transmission of discount-rate news through price changes.

What has been done up to now?

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Two distinct research streams were identified (the citation list is not exhaustive)

- ▶ Assess duration in a standard DCF framework: Ward (1988), Hartzell et al. (1988), Hamelink et al. (2000).
- ▶ Assess the interest-rate sensitivity of aggregate real estate indices: Annet (2005), Ayuso et al. (2003), Egert and Mihaljek (2007), Hoffman (2005), Hunt and Badia (2005) Iossifov et al. (2008), Meen (2002), Nagahata et al. ,OECD (2004a), Sutton (2002), Terrones and Otrok (2004), Verbruggen et al. (2005).

# Duration in the DCF framework

- ▶ Value computed using the DCF formula; constant discount rate and growth rates are assumed.
- ▶ Contractual rent switches to market rent at predetermined dates (every 5 years for U.K. property)
- ▶ The Macaulay duration is then analytically derived as the derivative of the PV w.r.t. the discount factor.
- ▶ A few quantities require an empirical estimate to allow the duration number to be computed: inflation flow-through rates, sensitivity of rents to changes in real interest rates.

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# Duration in the DCF framework - results

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Study	Duration	Remarks
Hamelink et al.	3.036	log-log regression
Hamelink et al.	3.15	Value using the cross-corr between growth and the discount
Hamelink et al.	3.57	Value using the cross-corr between changes in growth and discount
Ward	2.77 to 36.05	Duration values depend on yield level and on the maturity of inv.
Hartzell et al.	4.0	10 year lease and a discount rate of 11.3% - market frictions regime

Table: Duration values - overview of the existing studies

# Using this methodology for the Swiss case

- ▶ Constant discount rates are assumed.
- ▶ The quantities needing an empirical estimate are portfolio specific; no proper data was available.

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# Interest-rate sensitivity studies

- ▶ Focus of research is the response of the aggregate housing market in a broad macroeconomic analysis [Annet 2005, Terrones and Otrok 2004, Tsatsaronis and Zhu 2004, Sutton 2002].
- ▶ Multiple equation systems or panel models are employed most of the time using yearly data.
- ▶ Results from the literature give an interest-rate sensitivity for privately-owned homes or a index based on both owner and rental housing; almost no attention paid to rental housing as the focus of these studies is financial stability and long-run growth.
- ▶ lossifov et al. indicate that the broad range of results might be caused by the improper use of the econometric tools.

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# Interest-rate sensitivity studies -results

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Study	Interest-rate sensitivity	Remarks
Ayuso et. al. (2003)	-4.5	Spain
Egert and Mihaljek (2007)	-0.002 to -0.015	OECD countries
	-0.001 to -0.046	CEE countries
Hoffman (2005)	-9.42	Netherlands
Hunt and Badia (2005)	-6.0	U.K.
Iossifov et al. (2008)	-3.6	86 countries
Meen (2002)	-1.3	U.S.
	-3.5	U.K
Nagahata et al.	-0.6 to -4.5	Japan
OECD (2004a)	-7.1	Netherlands
Sutton (2002)	-0.05 to -1.5	
Terrones and Otrok (2004)	-0.5 to -1.0	
Verbruggen et al. (2005)	-5.9	Netherlands

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Table: Interest-rate sensitivity values - overview of the existing studies

# Using this methodology for the Swiss case

- ▶ A large amount of data is needed for the estimation.
- ▶ Most macro time series are available only on an yearly basis rendering the available sample too small to obtain meaningful results.

How are prices, cash-flows and discount factors related?

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# The Campbell-Shiller idea

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Let  $r_{t+1}$  be the log return at time  $t + 1$  and  $p_t$  the log price at time  $t$  :

$$\begin{aligned}r_{t+1} &\equiv \log(P_{t+1} + D_{t+1}) - \log(P_t) \\ &= p_{t+1} - p_t + \log(1 + \exp(d_{t+1} - p_{t+1})) \\ r_{t+1} &\approx k + \rho p_{t+1} + (1 - \rho)d_{t+1} - p_t\end{aligned}$$

where  $k$  and  $\rho$  are parameters of the linearization.

The approximation can be solved forward (subject to a terminal condition) to obtain a formula for the log-price (Campbell, Shiller 1987, J. of Finance):

$$p_t = \frac{k}{1 - \rho} + (1 - \rho) \sum_{j=0}^{\infty} \rho^j \mathbb{E}_t[d_{t+1+j}] - \sum_{j=0}^{\infty} \rho^j \mathbb{E}_t[r_{t+1+j}]$$

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# The Campbell-Shiller implementation

- ▶ The approximation relates today's price to future cash-flows and discount-rates linearly
- ▶ A change in the log price is then related to a revision in the expectations of future CF and discount rates.
- ▶ A measure for the expected variables is obtained through the use of a structural VAR

## But:

- ▶ The previous formula can be regarded as the rational process of price formation.
- ▶ Research in behavioral finance indicates that both appraisers and investors tend to extrapolate past info to predict the future (Wheaton and Torto (1989), Barkham and Ward (1999), Daly et al. (2003), Diaz III (1989),(1999), Diaz III and Wolverton (1998)); (Born and Pyhrr (1994)).

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# A potential solution

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- ▶ Use a different econometric specification for the pricing equation which preserves the linear structure and is consistent with the observed valuation behavior.
- ▶ A good candidate is an ADL (autoregressive distributed lag) model with exogenous variables rental values and discount rates:

$$x_t = \alpha + \sum_{i=1}^p \beta_{1i} x_{t-i} + \sum_{j=0}^q \beta_{2j} y_{t-j} + \sum_{k=0}^m \beta_{3k} z_{t-k} + \epsilon_t$$

- ▶ The lag-length selection procedure is dictated by the data and not imposed a priori (using some Information Selection Criterion)

# Using the method for the Swiss RE market

What is the "duration" of Swiss direct real estate?

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- ▶ For Switzerland the index measuring the performance of direct real estate is the IAZI Investment Index (available at quarterly values). The index is available since 1987 with roughly 6 years representing a generally-accepted bubble [Hoesli, Giaccotto 1997]
- ▶ It is a total return index used to compute the capital requirement of insurance companies investing in direct real estate [the reason why the analysis is done on this index].
- ▶ An index for cash-flows is unfortunately unavailable; a rental index of the BFS is used instead
- ▶ For the discount rate the 10-y Swiss Confederation bond yield is used

$$r_t^{IAZI} = \alpha + \sum_{i=1}^p \beta_{1i} r_{t-i}^{IAZI} + \sum_{j=0}^q \beta_{2j} r_{t-j}^{rents} + \sum_{k=0}^m \beta_{3k} r_{t-k}^{SNB} + \epsilon_t$$

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# The ADL model - first look

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The model using Swiss data is given as

$$\begin{aligned}r_t^{IAZI} &= \alpha + \beta_{14}r_{t-4}^{IAZI} + \beta_{20}r_t^{rents} + \beta_{21}r_{t-1}^{rents} + \\ &+ \beta_{30}r_t^{SNB} + \beta_{31}r_{t-1}^{SNB} + \beta_{32}r_{t-2}^{SNB} + \epsilon_t\end{aligned}$$

But the bond yield is autocorrelated implying the estimates will have large standard errors as is the case with this specification.



# The ADL model - estimates

Parameter	Value	Std. Error	p-value
$\alpha$	0.05	0.013	(0.0003)
$\beta_{14}$	-0.28	0.149	(0.0632)
$\beta_{20}$	1.21	0.839	(0.1549)
$\beta_{21}$	-1.13	0.859	(0.1911)
$\beta_{30}$	-5.52	5.040	(0.2781)
$\beta_{31}$	7.19	7.628	(0.3504)
$\beta_{32}$	-6.45	4.810	(0.1862)
Jarque-Bera	1.53		(0.4639)
Ljung-Box	24.05		(0.1181)
Durbin-Watson	1.66		
R-squared	0.24		
Adj. R-squared	0.15		

Table: Regression results - time period 1995-2008

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# The ADL model - transformation

- ▶ A transformation of variables is used in order to obtain a reliable estimate for the long-run impact of a change in bond yields.
- ▶ The transformation entails estimating the model using as explanatory variables

$$r_t^{SNB}, (r_t^{SNB} - r_{t-1}^{SNB}), (r_t^{SNB} - r_{t-2}^{SNB})$$

where the parameter estimate of  $r_t^{SNB}$  now becomes the long-run impact or propensity of a change in the bond yield (Wooldridge 2006).

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# The ADL model - transformed model

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$$\begin{aligned}r_t^{IAZI} &= \alpha + \beta_{14}r_{t-4}^{IAZI} + \beta_{20}r_t^{rents} + \beta_{21}r_{t-1}^{rents} + \\ &+ \beta_{30}^*r_t^{SNB} + \beta_{31}^*\widetilde{r_{t-1}^{SNB}} + \beta_{32}^*\widetilde{r_{t-2}^{SNB}} + \epsilon_t\end{aligned}$$

# The ADL model - transformed model estimates

Parameter	Value	Std. Error	p-value
$\alpha$	0.05	0.013	(0.0003)
$\beta_{14}$	-0.28	0.149	(0.0632)
$\beta_{20}$	1.21	0.839	(0.1549)
$\beta_{21}$	-1.13	0.859	(0.1911)
$\gamma$	<b>-4.78</b>	<b>1.586</b>	<b>(0.0041)</b>
$\beta_{31}$	-7.19	7.628	(0.3504)
$\beta_{32}$	6.45	4.810	(0.1862)
Jarque-Bera	1.53		(0.4639)
Ljung-Box	24.05		(0.1181)
Durbin-Watson	1.66		
R-squared	0.24		
Adj. R-squared	0.15		

**Table:** Regression results using the transformed model - time period 1995-2008

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# The ADL model - transformed model estimates II

Parameter	Value	Std. Error	p-value
$\alpha$	0.04	0.009	(0.0000)
$\beta_{14}$	-0.22	0.124	(0.0684)
$\beta_{20}$	0.54	0.249	(0.0331)
$\beta_{21}$	0.5424	0.246	(0.0689)
$\gamma$	-4.56	1.049	(0.0000)
$\beta_{31}$	-2.77	5.096	(0.5880)
$\beta_{32}$	5.12	3.172	(0.1103)
Jarque-Bera	2.81		(0.2453)
Ljung-Box	18.57		(0.4186)
Durbin-Watson	1.91		
R-squared	0.22		
Adj. R-squared	0.16		

**Table:** Regression results using the transformed model - time period 1988-2008

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# The ADL model - transformed model estimates

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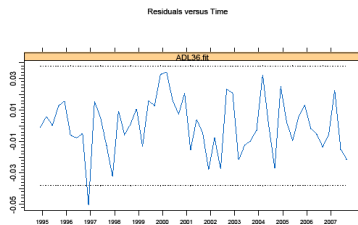
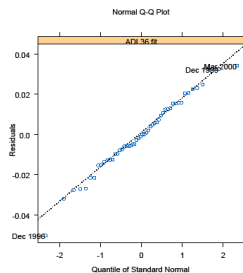
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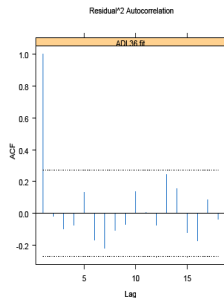
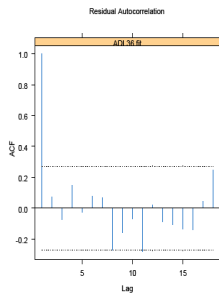
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# A few conclusions

- ▶ Only the long-run impact is obtained with sufficient reliability - given a 1% permanent increase in the bond yield one expects a roughly 4.5% drop in the IAZI performance index.
- ▶ Thus an interest-rate sensitivity is obtained - this is nevertheless *not* the same as a duration number.
- ▶ Given the normal errors and their lack of autocorrelation, the OLS residuals can be used for historical simulation in order to obtain a distribution of returns for the next period.



# The Swiss Direct Real Estate Market

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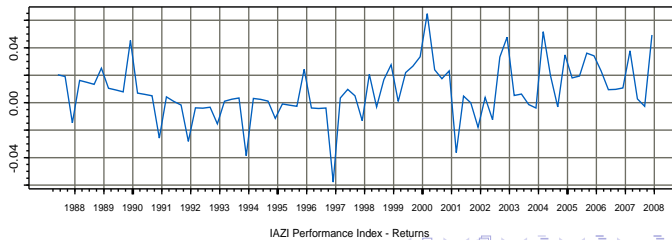
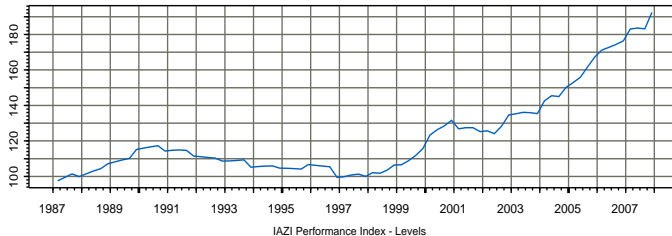
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# The rental market

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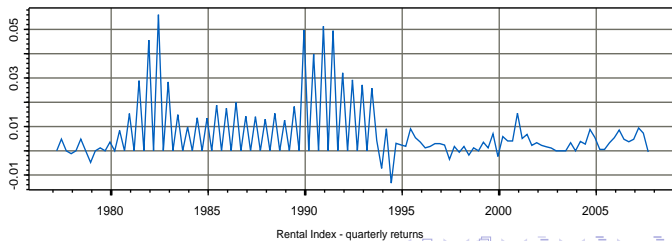
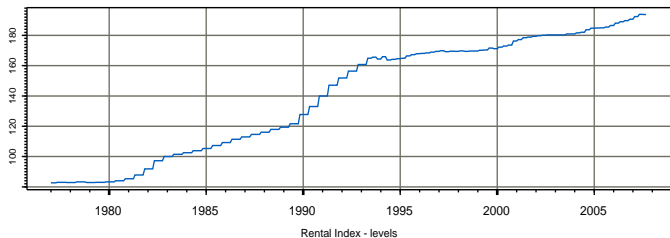
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# The discount factor

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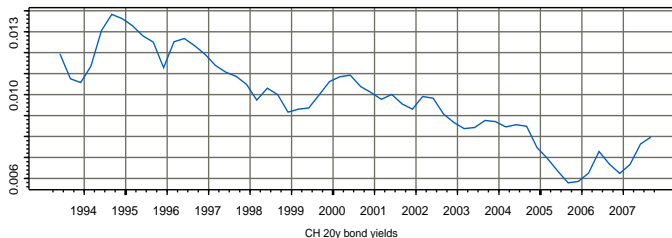
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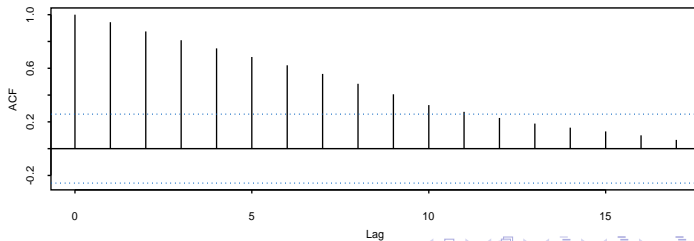
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Series : All.Ret[, "SNB.20Y"]



# The discount factor - unit root test

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`summary(ADF.unit20y)`

**Test for Unit Root:** Augmented DF Test

**Null Hypothesis:** there is a unit root

**Type of Test:** t-test

**Test Statistic:** -4.395

**P-value:** 0.004781

**Coefficients:**

	Value	Std. Error	t value	Pr(> t )
lag1	-0.3512	0.0799	-4.3945	0.0001
lag2	0.4373	0.1176	3.7180	0.0005
constant	0.0046	0.0011	4.3699	0.0001
time	-0.0024	0.0006	-4.1726	0.0001

**Regression Diagnostics:**

**R-Squared** 0.3249

**Adjusted R-Squared** 0.2860

**Durbin-Watson Stat** 2.0935

**Residual standard error:** 0.000485 on 52 degrees of freedom

**F-statistic:** 8.342 on 3 and 52 degrees of freedom, the p-value is 0.0001263