Default when Current House Values are Uncertain

Morris A. Davis and Erwan Quintin

Rutgers University and Wisconsin School of Business

November, 2014

Introduction

How does uncertainty about current value affect default?

What we do:

- Preliminary evidence
- Specify a default model
- Estimate parameters of the model
  - Panel data on self-reported prices and price indexes
  - Panel data on mortgage defaults
- Run counterfactual experiment

Introduction

Findings:

- Significant estimates of homeowner uncertainty
  - Kalman gain of 55 percent
  - Homeowner uncertainty, 95% CI $\pm$ 8.3 percent
- Simple default model explains much of the data
  - Fits relationship of LTV and default rates for LTVs$>$100
  - Default model systematically misses along a few dimensions
- Experiment: Uncertainty about current home value reduced defaults by 25% in 2010-11

  (cohort of prime mortgages issued in 2006, 80% LTV at origination)

Data

- Self-assessed house prices from
  - The 2000 Decennial Census of Housing
  - The 2005-2011 annual American Community Survey
- These data sets offer large sample sizes relative to American Housing Survey / Survey of Consumer Finances
- Compare self-assessed house prices to Case-Shiller-Weiss
  - 20 Metro Areas covered by Case-Shiller-Weiss
  - Identical geographic areas except Chicago and NYC
  - Single-family attached and detached.
- All data adjusted for inflation

Data

MSA	Sample Sizes, Self-Reported House Value 5% Census 2000	ACS 2005-2011 Average	ACS 2005-2011 Std. Dev.
BOS	30,588	7,731	167
CHI	66,584	16,357	869
DAL	42,525	12,967	407
DET	39,689	9,316	514
LV	11,319	3,769	177
LA	82,064	19,713	579
MIA	14,148	3,473	101
NYC	100,842	23,524	454
PHO	29,324	8,544	476
SD	20,526	5,297	209
SF	38,864	9,120	333
SEA	20,524	5,552	68
TAM	24,491	7,026	217
DC	46,335	12,016	271

	Average of Self-Reported House Prices Thousands of $2005 Dollars							
MSA	2000	2005	2006	2007	2008	2009	2010	2011
BOS	310	480	475	464	455	432	423	401
CHI	224	301	314	315	312	289	270	250
DAL	152	178	183	187	190	188	184	178
DET	183	217	213	206	190	159	142	132
LV	184	355	374	369	317	236	198	176
LA	328	585	626	618	637	560	539	513
MIA	184	338	378	381	377	306	272	241
NY	296	486	508	502	510	483	457	437
PHO	184	292	349	341	321	261	233	200
SD	314	610	615	590	572	500	472	454
SF	434	663	682	663	716	618	593	556
SEA	305	398	438	466	474	438	410	373
TAM	137	233	275	265	251	210	196	173
DC	258	471	507	500	480	439	418	399
Median	209	305	340	345	319	294	271	246
Standard Dev	76	147	151	146	154	137	134	130

Data

2 interesting features of (real) self-reported house prices

1. Peak about 1 year after CSW
2. Boom (2000 - CSW peak) and Bust (CSW peak - 2011)
   - Highly correltaed with CSW
   - Decline much steeper in CSW than SR

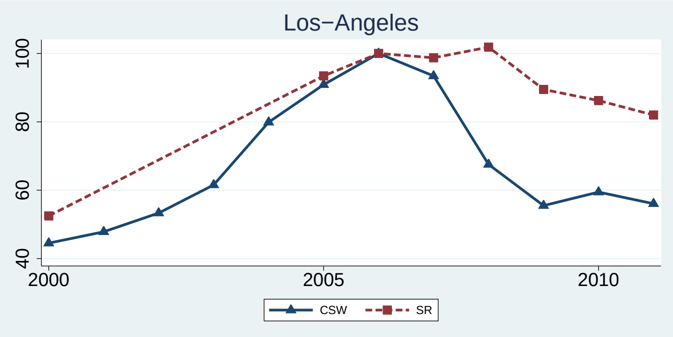
Data

	Peak Date		
MSA	AVG	CSW	AVG-CSW
BOS	2005	2005	0
CHI	2007	2006	1
DAL	2008	2002	6
DET	2005	2005	0
LV	2006	2006	0
LA	2008	2006	2
MIA	2007	2006	1
NY	2008	2006	2
PHO	2006	2006	0
SD	2006	2005	1
SF	2008	2006	2
SEA	2008	2007	1
TAM	2006	2006	0
DC	2006	2006	0
Median	2007	2006	1
Standard Dev	1	1	1

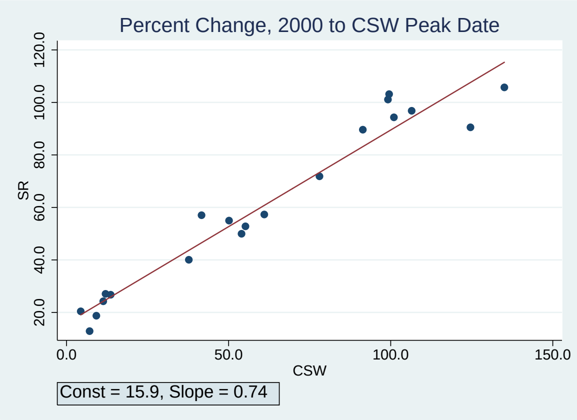
Data

MSA	Real Percent Chg. from CSW Peak AVG	CSW	Difference
BOS	-16.5	-25.1	8.6
CHI	-20.4	-37.5	17.1
DAL	-2.6	-15.9	13.4
DET	-39.2	-51.4	12.2
LV	-52.8	-63.1	10.2
LA	-18.0	-43.9	25.9
MIA	-36.3	-54.7	18.5
NY	-14.1	-30.3	16.2
PHO	-42.7	-60.0	17.4
SD	-25.6	-44.5	18.9
SF	-18.5	-44.2	25.7
SEA	-20.0	-33.6	13.6
TAM	-37.0	-51.2	14.1
DC	-21.3	-34.0	12.7
Median			13.9

Data

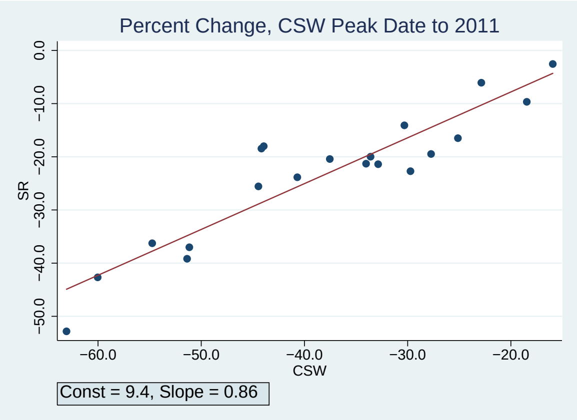


Data



Percent Change, 2000 to CSW Peak Date
SR
20.0
40.0
60.0
80.0
100.0
120.0
0.0
50.0
100.0
150.0
CSW
Const = 15.9, Slope = 0.74

Data



End Year	Coeff	SE	$R2$
2009	0.58	0.08	$R2 = 0.74$
2010	0.74	0.08	$R2 = 0.82$
2011	0.86	0.09	$R2 = 0.85$

Default Model - Prices

- True but unobserved log house prices h^*

$$h_t^* = \rho h_{t-1}^* + e_t \tag{1}$$

- Observed signal h_s

$$h_{st} = h_t^* + \nu_t \; .$$

- If $\kappa_t = \kappa$, then optimal update of beliefs h_b

$$h_{bt} = (1-\kappa)\,\rho h_{bt-1} + \kappa h_{st} \tag{2}$$

Default Model - Decision

- Value of selling ("terminating") V^T

$$V^T(h_b; d) \quad = \quad E\left[\max\left(\exp\left\{h^*\right\} - d, -c\right) \mid h_b; d\right] + V^o$$

- Value of staying V^C

$$V^C(h_b, \epsilon; d) \quad = \quad \epsilon + \beta E\left[W\left(h_b', d\right) \mid h_b\right]$$

- Expeced value of house before ϵ known W

$$W(h_b; d) =$$

$$P\left[\epsilon < \epsilon^*(h_b, d)\right] V^T(h_b; d) + P\left[\epsilon \geq \epsilon^*(h_b, d)\right] \frac{\int_{\epsilon^*(h_b,d)}^{+\infty} V^C(h_b, \epsilon; d)\, d\epsilon}{\int_{\epsilon^*(h_b,d)}^{+\infty} d\epsilon}$$

Default Model - Parameter Summary

Parameter	Description
ρ	persistence, log true house prices
σ_e	SD, shock to log true house prices
σ_ν	SD, signal noise
κ	Kalman gain
β	Discount factor
c	NPV of all default costs
V^o	NPV of outside option
σ_ϵ	SD, shock to preferences

Variance of prior: $$\frac{(1-\kappa)\,\sigma_e^2}{1-(1-\kappa)\,\rho^2}$$

Estimation - Belief Parameters

- Allow for mean, average equation (2) across hh in an MSA

$$H_{bmt} = (1-\kappa)\left[\bar{H}_m + \rho H_{bmt-1}\right] + \kappa H_{smt} \quad (3)$$

- Econometrician observes signal with error and mean shift

$$\mathcal{H}_{mt} = H_{smt} - \alpha_m - u_{mt} \quad (4)$$

- Insert (4) into (3)

$$H_{bmt} = a_m + (1-\kappa)\rho H_{bmt-1} + \kappa \mathcal{H}_{mt} + \kappa u_{mt}$$
$$a_m = (1-\kappa)\bar{H}_m + \kappa \alpha_m$$

- Use ACS self-report for H_b and CSW data for $\mathcal{H}$

Estimation - Belief Parameters

- Can use Maximum Likelihood

$$
\begin{aligned}
H_{bmt} &= a_m + (1-\kappa)\,\rho H_{bmt-1} + \kappa \mathcal{H}_{mt} - \kappa u_{mt} \\
\rightarrow u_{mt} &= \mathcal{H}_{mt} - \kappa^{-1}\left[H_{bmt} - a_m - (1-\kappa)\,\rho H_{bmt-1}\right]
\end{aligned}
$$

- Likelihood function

$$
\mathcal{L}(\theta) = \frac{1}{N}\sum_{n=1}^{N}\left[\sum_{m=1}^{20}\tilde{\ell}(\theta)_{mt=2005}\right] + \sum_{m=1}^{20}\sum_{t=2006}^{2011}\ell(\theta)_{mt}
$$

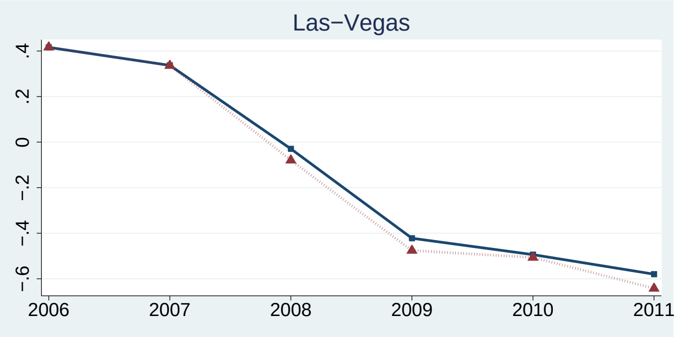
- First term - simulate $H_{bmt=2004}$ given $H_{bmt=2000}$

Estimates

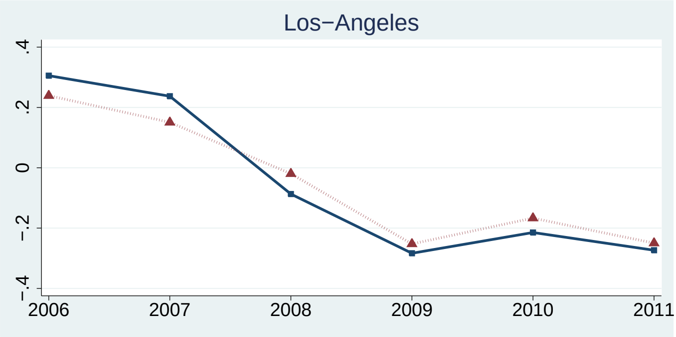
Maximum Likelihood Estimates and Standard Errors
Annual panel data, 20 MSAs from 2007-2011

Parameter	Estimate	Standard Error
ρ	0.9919	0.0353
κ	0.5537	0.0121
σ_u	0.0454	0.0030

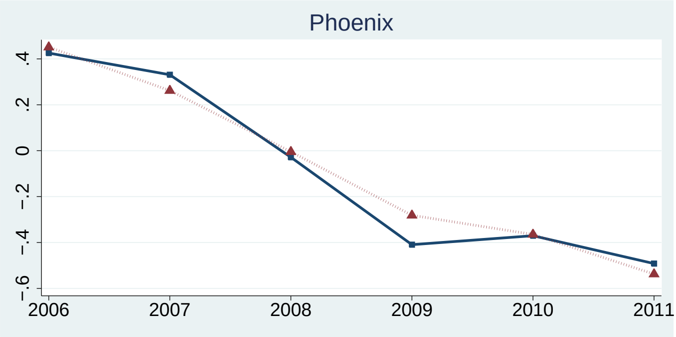
Analysis - H_{smt} and $\mathcal{H}_{mt}$



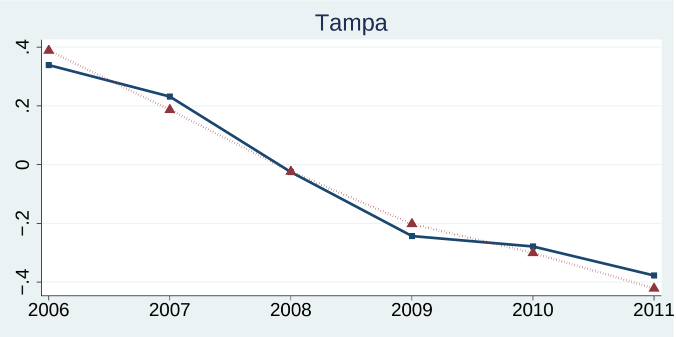
Analysis - H_{smt} and $\mathcal{H}_{mt}$



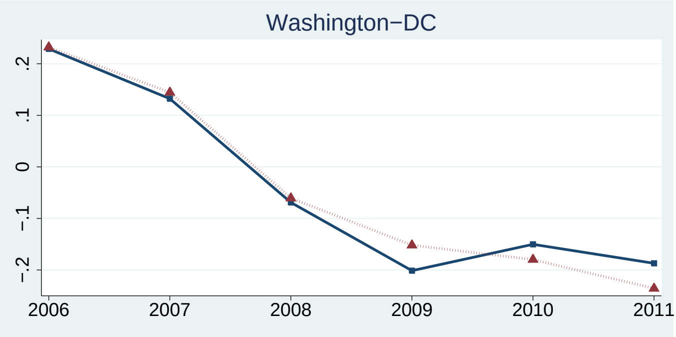
Analysis - H_{smt} and $\mathcal{H}_{mt}$



Analysis - H_{smt} and $\mathcal{H}_{mt}$



Analysis - H_{smt} and $\mathcal{H}_{mt}$



Analysis

- What do rolling forecasts look like, starting from 2000?

  1. Set all parameters to their estimated values
  2. Generate sequence of H_{bmt} given year-2000 starting value

$$H_{bmt} = a_m + (1-\kappa)\,\rho H_{bmt-1} + \kappa \mathcal{H}_{mt}$$

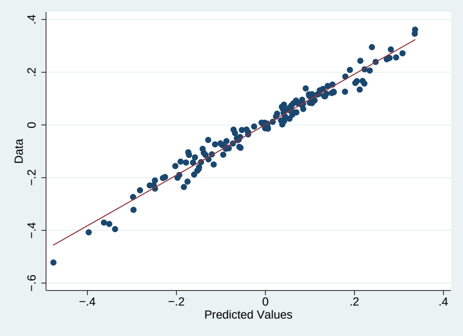
$\mathcal{H}_{mt}$ is data

H_{bmt-1} is entirely from model prediction

Weight on 2000 data in 2005 is $0.018 = [(1-0.55)\,0.99]^5$

Analysis

Figure: Comparison of H_{bmt} to predicted values, 2005-2011



$$H_{bmt} = \underset{(0.002)}{0.001} + \underset{(0.014)}{0.959} * \text{Predicted}$$

Note: An estimate of $\bar{H}_m / (1-\rho)$ is subtracted from all data

Demeaned values of H_{bmt}

	2006	2007	2008	2009	2010	2011
BOS	0.111	0.082	-0.013	-0.057	-0.089	-0.150
CHI	0.109	0.118	0.047	-0.031	-0.106	-0.198
DAL	0.032	0.046	0.005	-0.006	-0.017	-0.061
DET	0.249	0.209	0.069	-0.139	-0.273	-0.370
LV	0.362	0.346	0.109	-0.215	-0.376	-0.522
LA	0.166	0.157	0.059	-0.114	-0.143	-0.201
MIA	0.239	0.254	0.139	-0.091	-0.241	-0.395
NY	0.102	0.093	0.024	-0.036	-0.084	-0.141
PHO	0.286	0.272	0.118	-0.104	-0.248	-0.407
SD	0.206	0.159	0.012	-0.143	-0.190	-0.228
SF	0.167	0.134	0.077	-0.114	-0.156	-0.229
SEA	0.064	0.137	0.088	0.001	-0.070	-0.174
TAM	0.243	0.211	0.080	-0.076	-0.200	-0.322
DC	0.153	0.148	0.032	-0.070	-0.131	-0.188

Analysis

- If we assume common shocks to true house prices and signals inside each MSA we can estimate σ_ν^2 and σ_ϵ^2.
- At $\rho = 0.99$ and $\kappa = 0.55$
  estimate $\sigma_\nu = 0.056$ and $\sigma_e = 0.046$
  - SD of shocks to home prices is 4.6 percent per year
  - SD of gap between signal and true home value is 5.6 percent
  - Implied SD of homeowner prior: 4.14 percent
- Kalman gain converges to steady-state value in 1-2 years
  - Year 1: 41.0 percent
  - Year 2: 52.4 percent
  - Year 3: 54.8 percent
  - Year 4: 55.2 percent

Estimation - Preference Parameters

- Given belief parameters, estimate c, V^o, σ_ϵ
- Procedure: Match model predicted default rates to data
- Panel data from Freddie Mac, 2006 originations
  - 100 data points:
    5 years, 20 MSAs, CLTV at origination of 80
  - Panel data on mortgages, not households
  - Default occurs if continuous missed payments to D180
  - Default rate = Default starts during year / Stock in Jan

Estimation - Preference Parameters

- Can estimate default parameters using maximum likelihood

$$\sum_{\tau=1}^{5} \left\{ D_\tau \ln \left[\prod_{t=1}^{\tau-1} (1-\phi_t) \right] \phi_\tau \; + \; E_\tau \ln \left[\prod_{t=1}^{\tau-1} (1-\phi_t) \right] (1-\phi_t) \right\}$$

  D_τ are defaults in year τ

  E_τ are exits in year τ from prepays

- Benefit of ML – Optimal weights on sample observations
  For robustness, we also estimate using method of moments

Estimation - Example from Boston (1788 starting obs)

Year	Outcome	Frequency	Contribution to Lik
2007	Default	21	$\ln \phi_1$
	Prepay	203	$\ln (1 - \phi_1)$
2008	Default	50	$\ln \left[\prod_{t=1}^{1} (1 - \phi_t) \right] \phi_2$
	Prepay	210	$\ln \left[\prod_{t=1}^{1} (1 - \phi_t) \right] (1 - \phi_2)$
2009	Default	57	$\ln \left[\prod_{t=1}^{2} (1 - \phi_t) \right] \phi_3$
	Prepay	335	$\ln \left[\prod_{t=1}^{2} (1 - \phi_t) \right] (1 - \phi_3)$
2010	Default	27	$\ln \left[\prod_{t=1}^{3} (1 - \phi_t) \right] \phi_4$
	Prepay	191	$\ln \left[\prod_{t=1}^{3} (1 - \phi_t) \right] (1 - \phi_4)$
2011	Default	22	$\ln \left[\prod_{t=1}^{4} (1 - \phi_t) \right] \phi_5$
	Sample End	672	$\ln \left[\prod_{t=1}^{4} (1 - \phi_t) \right] (1 - \phi_5)$
	Total	1788	

Freddie Mac Data

year	Sample Size		Default Rate	
	Average	Std. Dev.	Average	Std. Dev.
2007	2322	1610	0.90	0.49
2008	2162	1490	3.63	2.88
2009	1885	1273	8.36	6.65
2010	1385	926	6.93	5.10
2011	1040	682	6.26	4.26

Default Model - Parameter Estimates

Parameter	Description	Estimate
β	Discount factor	0.95
c	NPV of all default costs	0.00
V^o	NPV of outside option	-0.001
σ_ϵ	SD, shock to preferences	0.0711

Model Fit

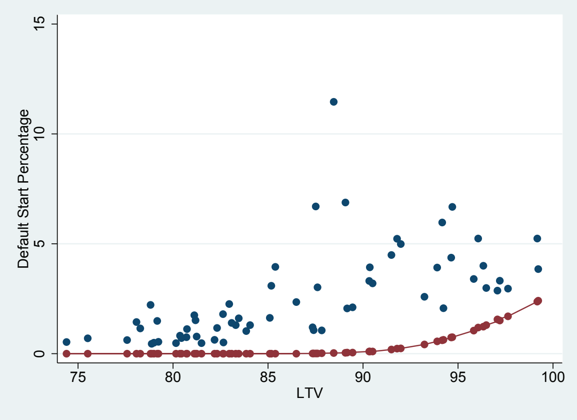
Averaged by Year

Year	Data	Predicted	Error
2007	0.90	0.00	0.90
2008	3.63	0.39	3.25
2009	8.36	3.41	4.96
2010	6.93	4.93	2.00
2011	6.26	6.96	-0.70

This is not as bad as it seems:

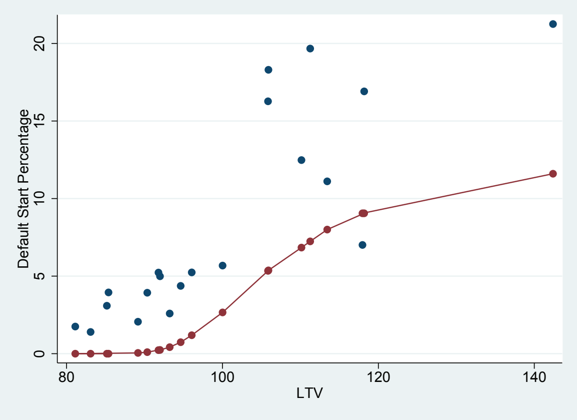
- Model cannot rationalize defaults with LTV < 95 explains 2007 and 2008
- Model cannot explain 2009 given 2010 and 2011 LTVs continued to rise but default rates fell

Model Fit - LTV < 100, All Years



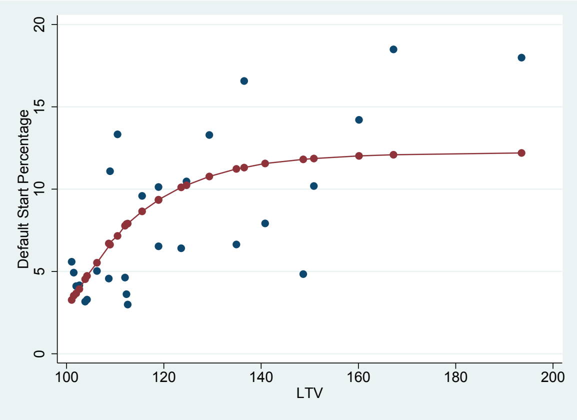
Blue = data, red = model predicted

Model Fit - 2009



Blue = data, red = model predicted

Model Fit - 2010 and 2011, LTV > 100



Regression of Data on Model:

Constant 0.000 (2.12), Slope of 0.992 (0.24), $R2$ of 41%.

Counterfactual Experiment

- Suppose people knew current house value w/ certainty
  By how much would defaults have increased?
- Focus on 2010 and 2011
- Compare Predicted Default
  - Baseline: $\sigma_\nu = 0.0556$
  - Experiment: $\sigma_\nu = 0.0$
- Average (20 MSAs) increase of 1.54 ppt.
  On a base of 5.95 ppt. = 25.9% increase

MSA	LTV	Data Default Rate	Simulated Default Rates $\sigma_{nu} = 0.0556$	Simulated Default Rates $\sigma_{\nu} = 0.0$	Increase
	(1)	(2)	(3)	(4)	(5)
DAL	86	1.18	0.01	0.01	0.00
SEA	96	4.71	1.86	3.03	1.16
NYC	99	4.06	2.45	4.09	1.64
BOS	101	3.07	3.11	5.15	2.03
CHI	104	4.90	4.54	6.98	2.44
DC	109	4.01	6.72	9.89	3.17
LA	112	10.34	7.64	10.69	3.05
SF	115	11.73	8.26	11.07	2.81
SD	121	6.47	9.73	11.82	2.09
TAM	133	9.19	10.90	12.10	1.20
MIA	140	11.74	11.32	12.17	0.85
DET	142	5.74	11.52	12.20	0.68
PHO	148	15.39	11.67	12.22	0.55
LV	180	18.24	12.15	12.25	0.10
Average		6.60	5.95	7.48	1.54