



# Regression: Predicting House Prices



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# Predicting house prices

# How much is my house worth?



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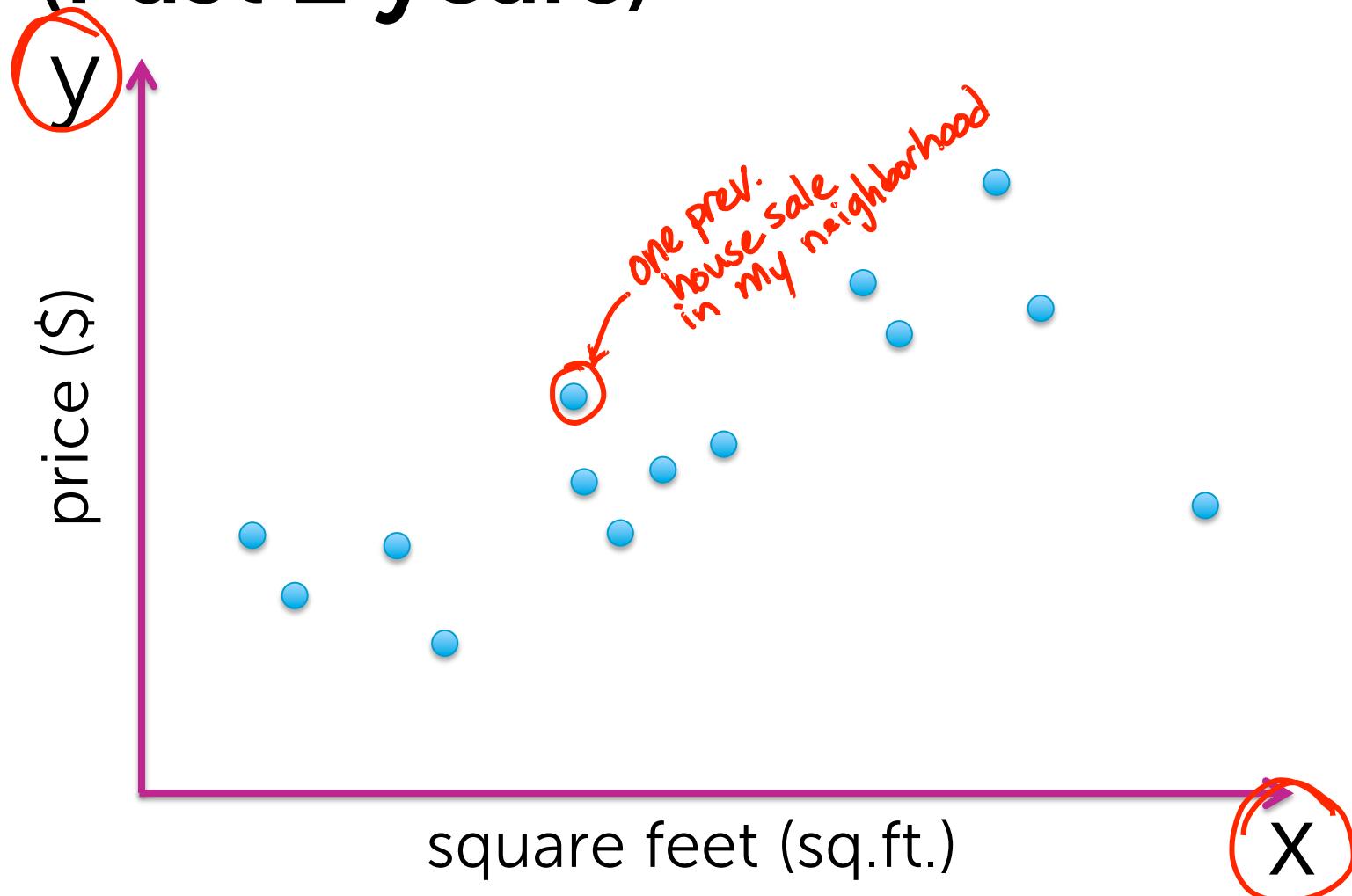


# Look at recent sales in my neighborhood

- How much did they sell for?



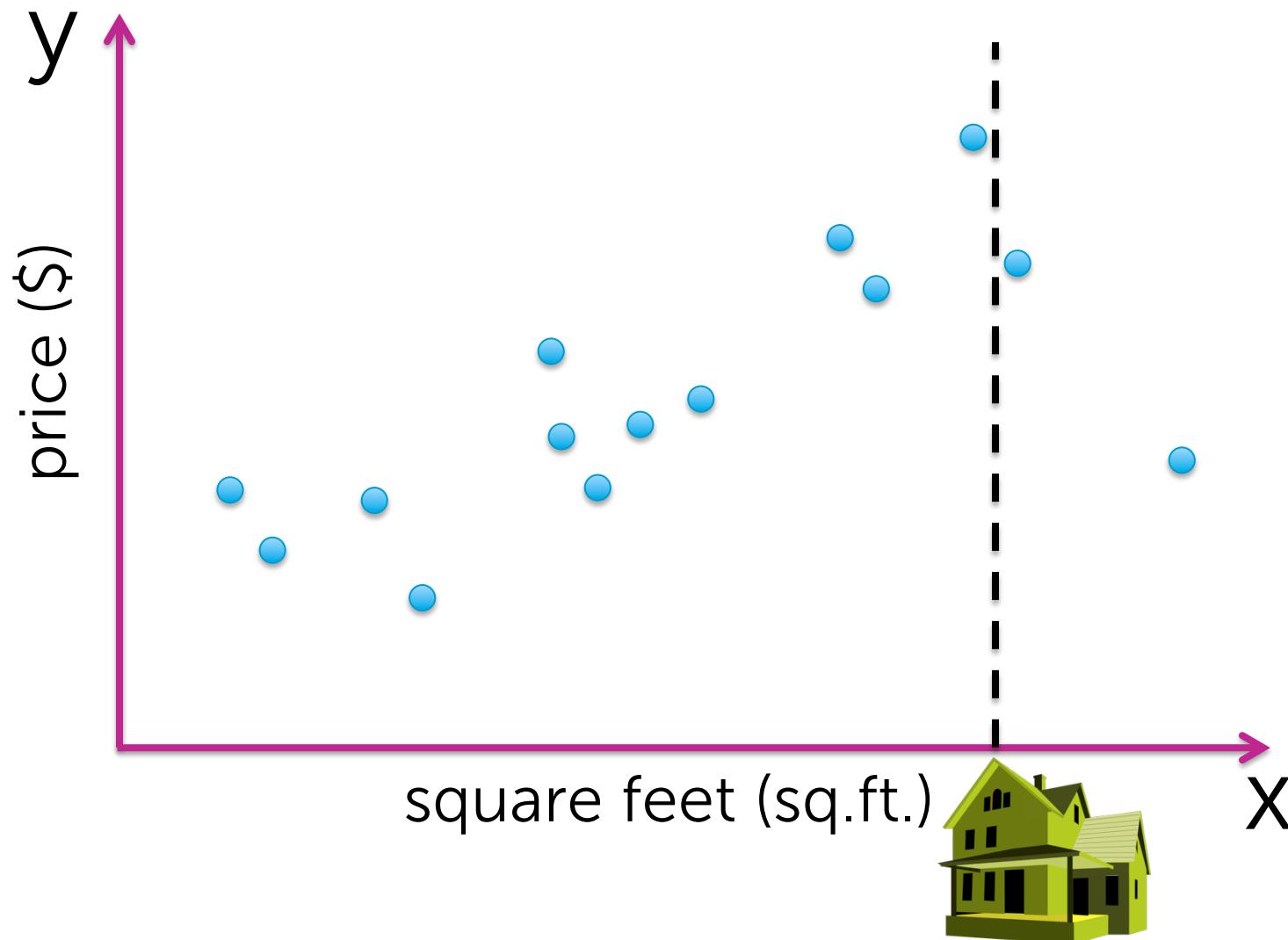
# Plot recent house sales (Past 2 years)



**Terminology:**

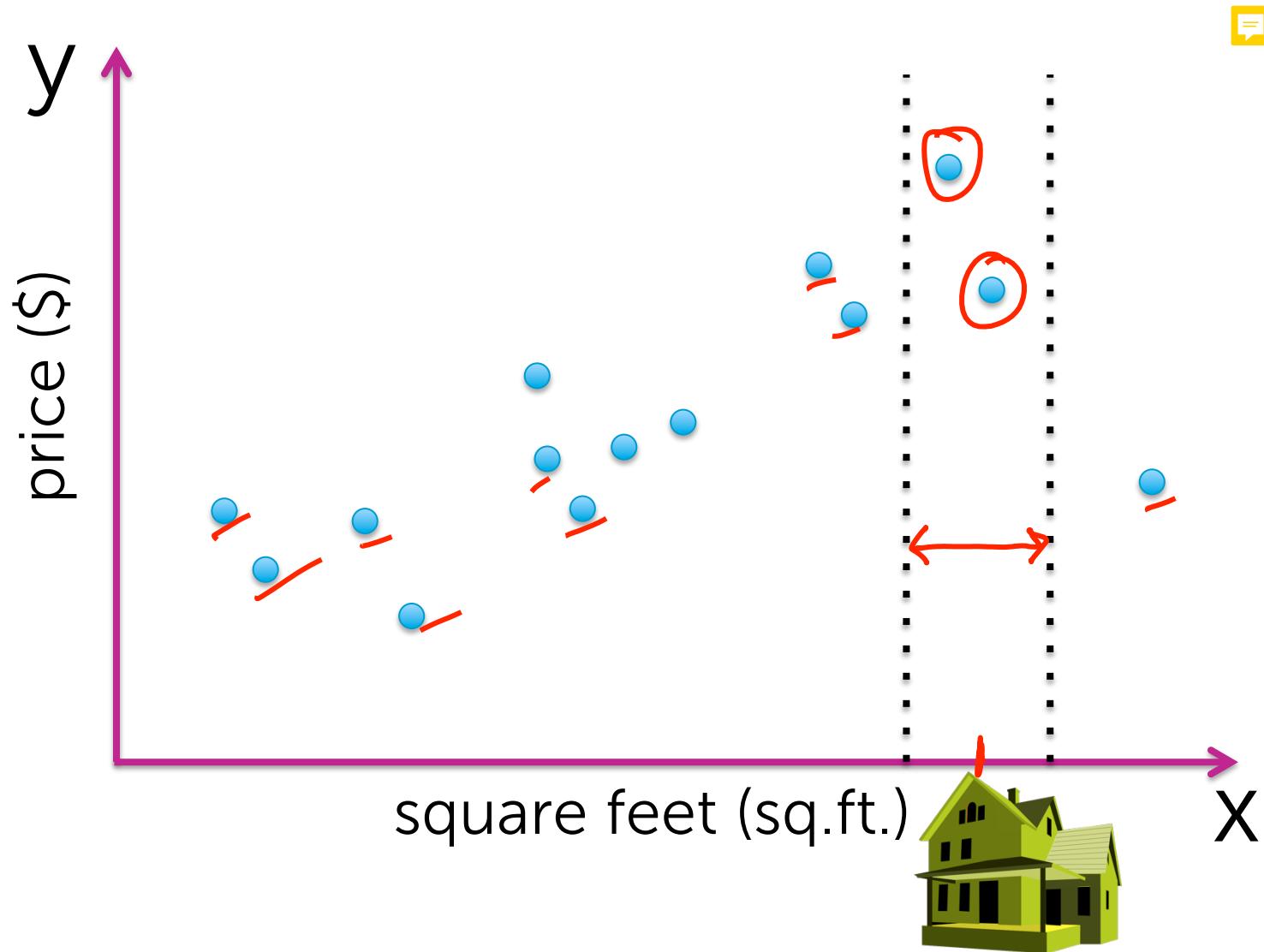
- x – feature, covariate, or predictor
- y – observation or response

# Predict your house by similar houses



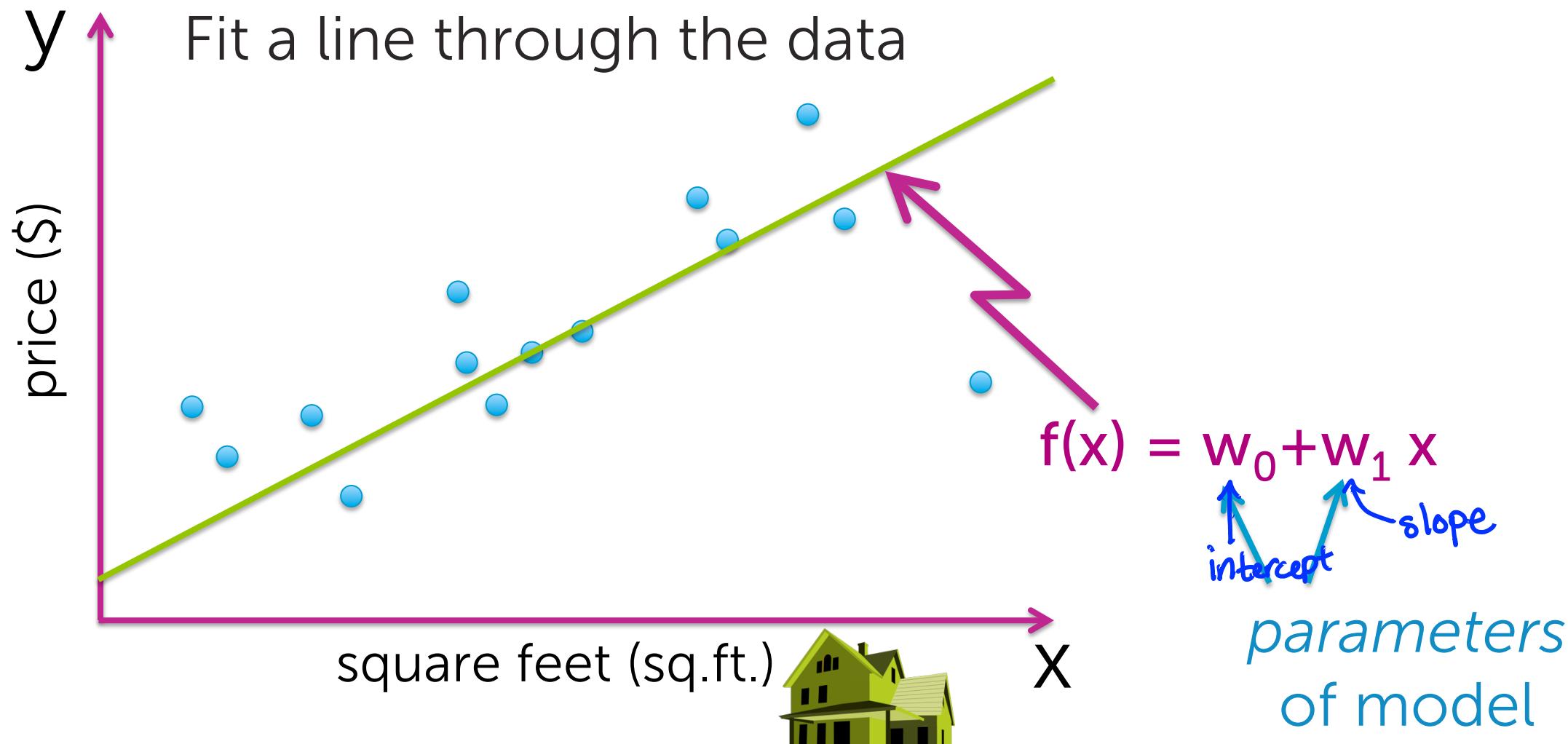
No house sold recently had *exactly* the same sq.ft.

# Predict your house by similar houses

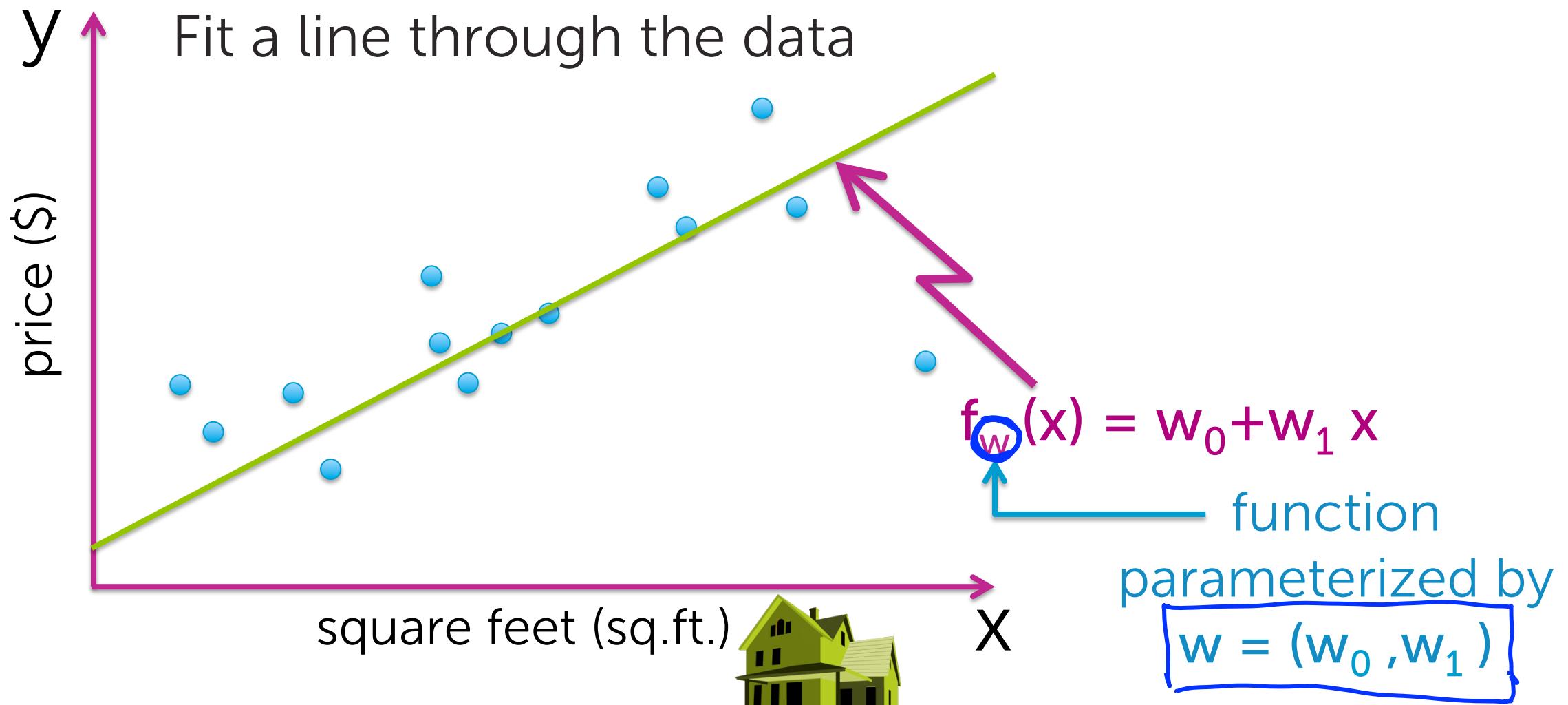


# Linear regression

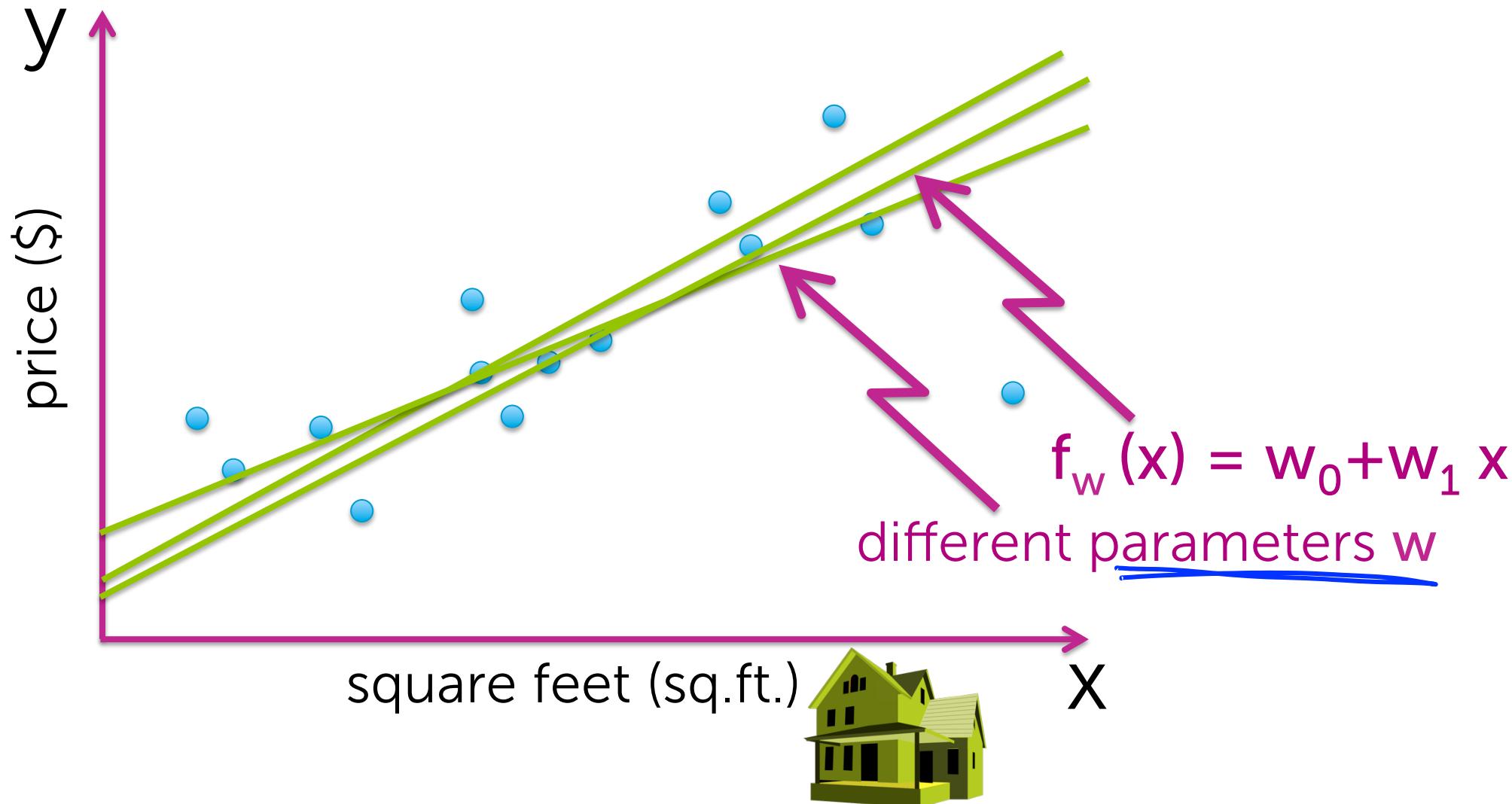
# Use a **linear** regression model



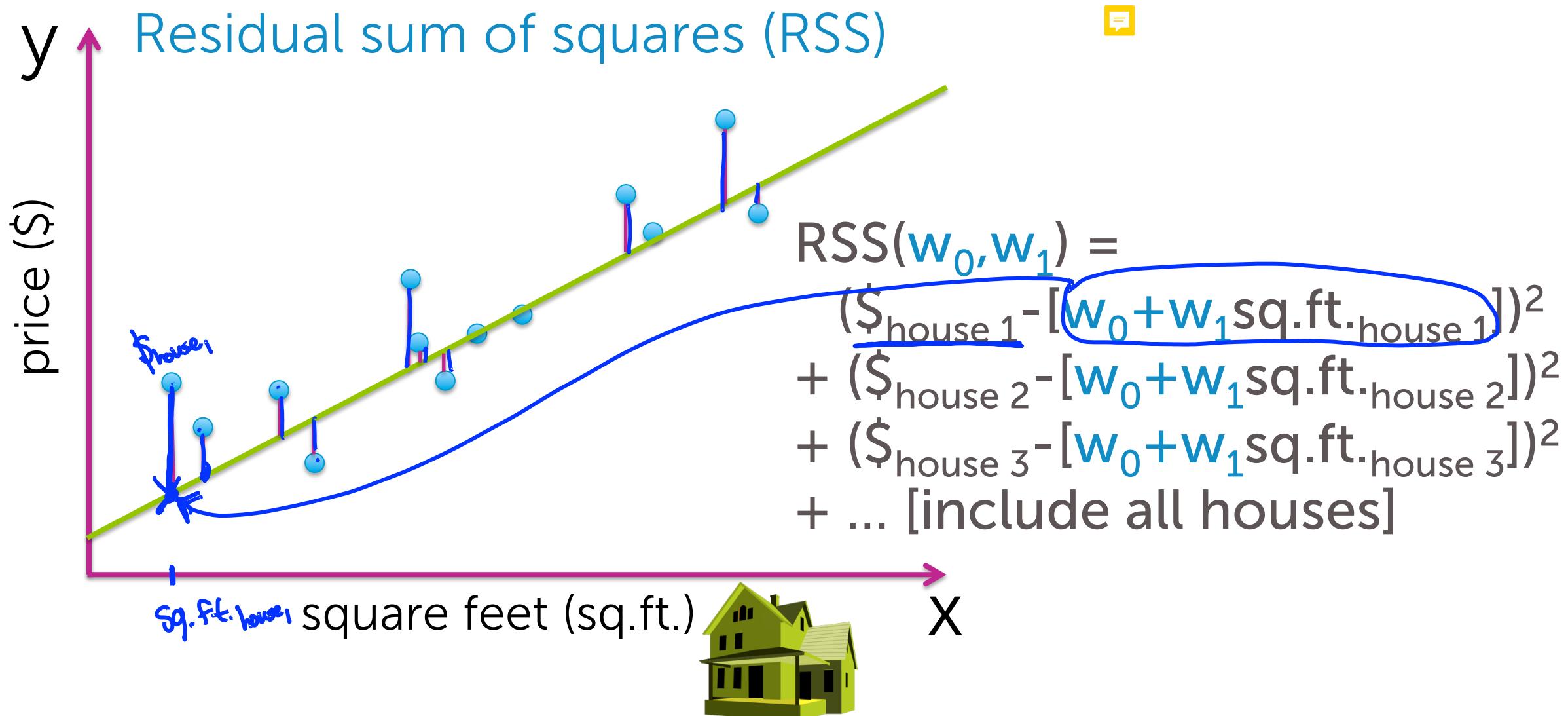
# Use a linear regression model



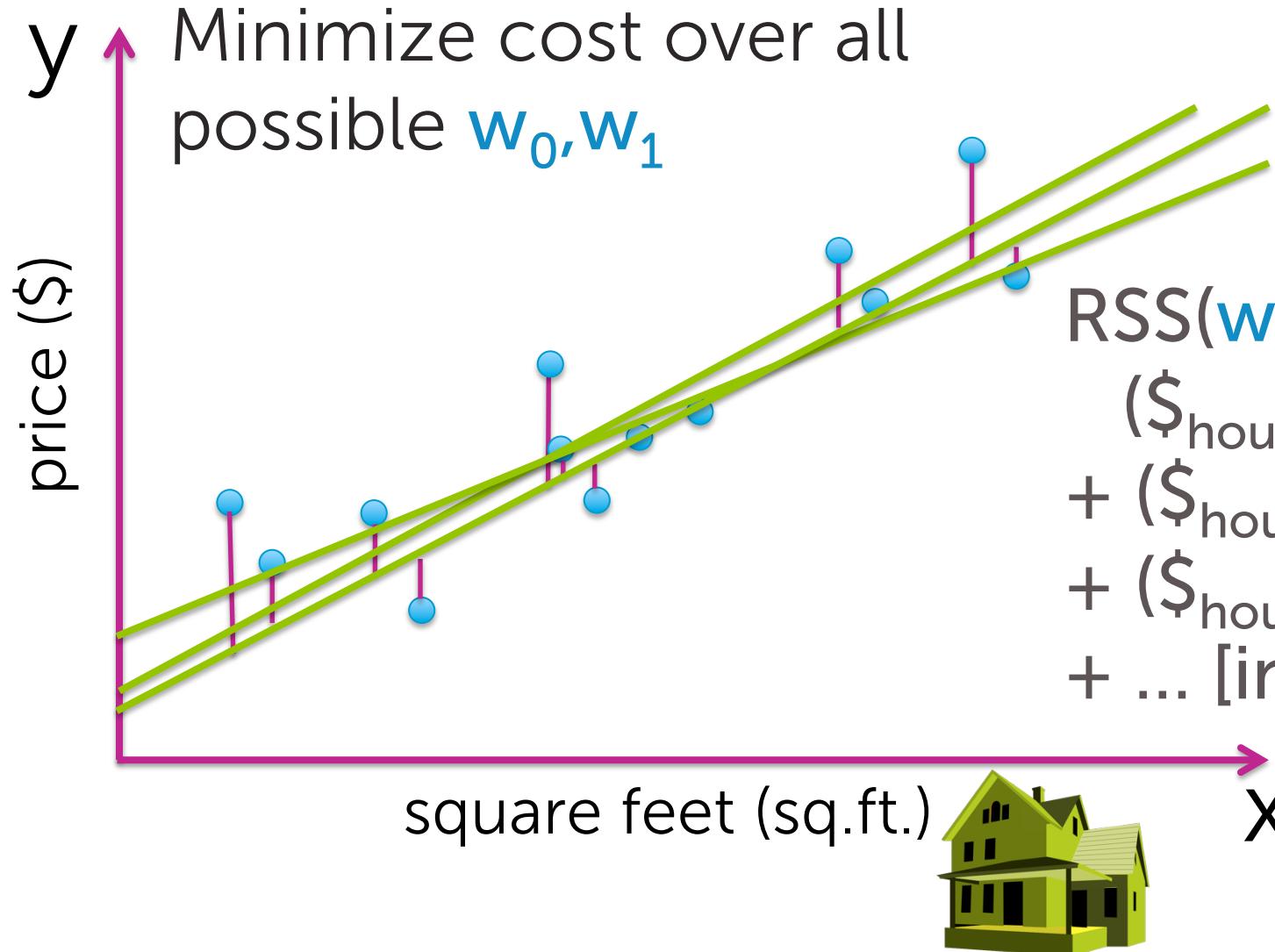
# Which line?



# "Cost" of using a given line



# Find “best” line

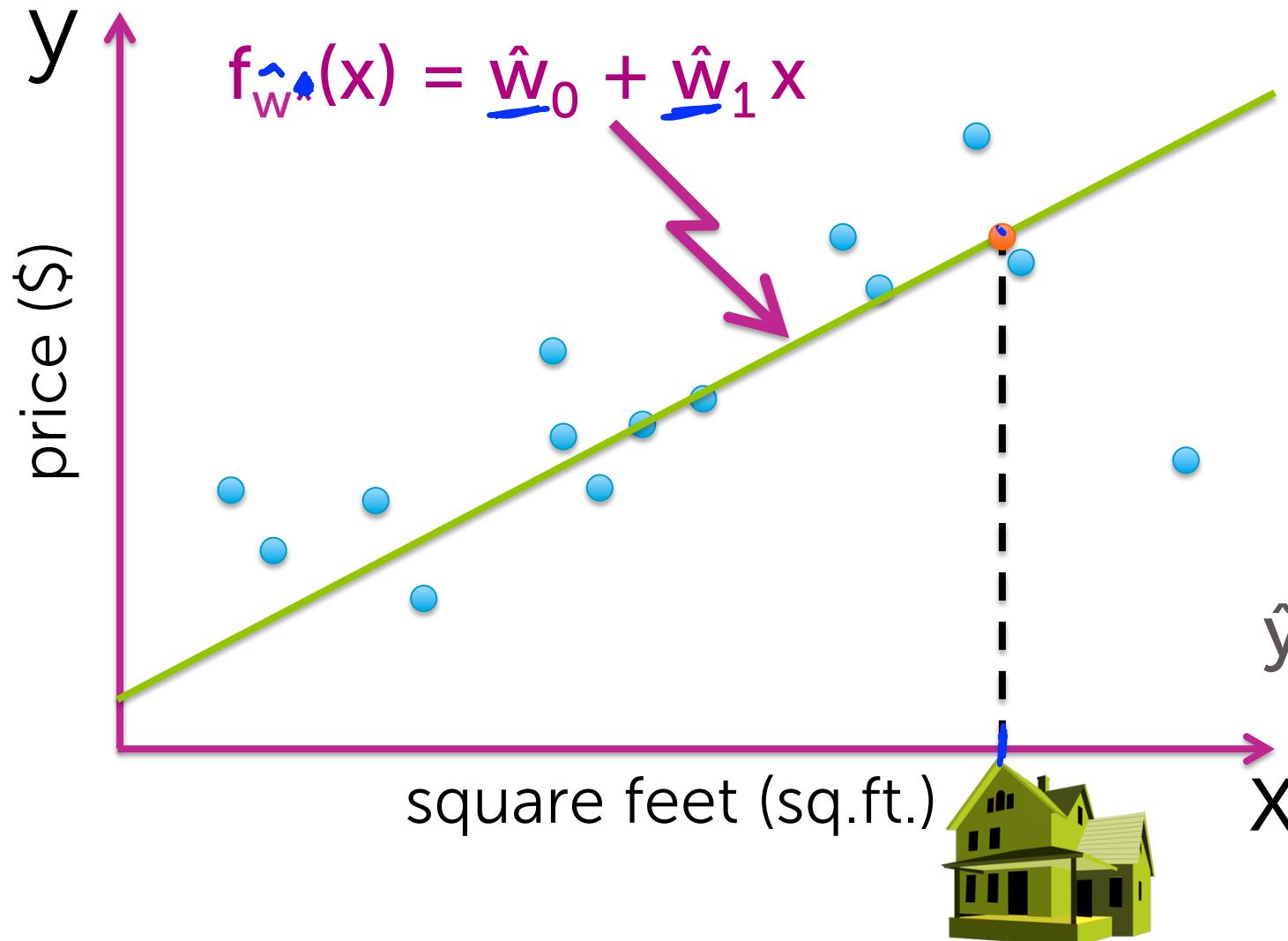


RSS( $w_0, w_1$ ) =  
 $(\$_{\text{house 1}} - [w_0 + w_1 \text{sq.ft.}_{\text{house 1}}])^2$   
+  $(\$_{\text{house 2}} - [w_0 + w_1 \text{sq.ft.}_{\text{house 2}}])^2$   
+  $(\$_{\text{house 3}} - [w_0 + w_1 \text{sq.ft.}_{\text{house 3}}])^2$   
+ ... [include all houses]

↓

$$\hat{W} = (\hat{w}_0, \hat{w}_1)$$

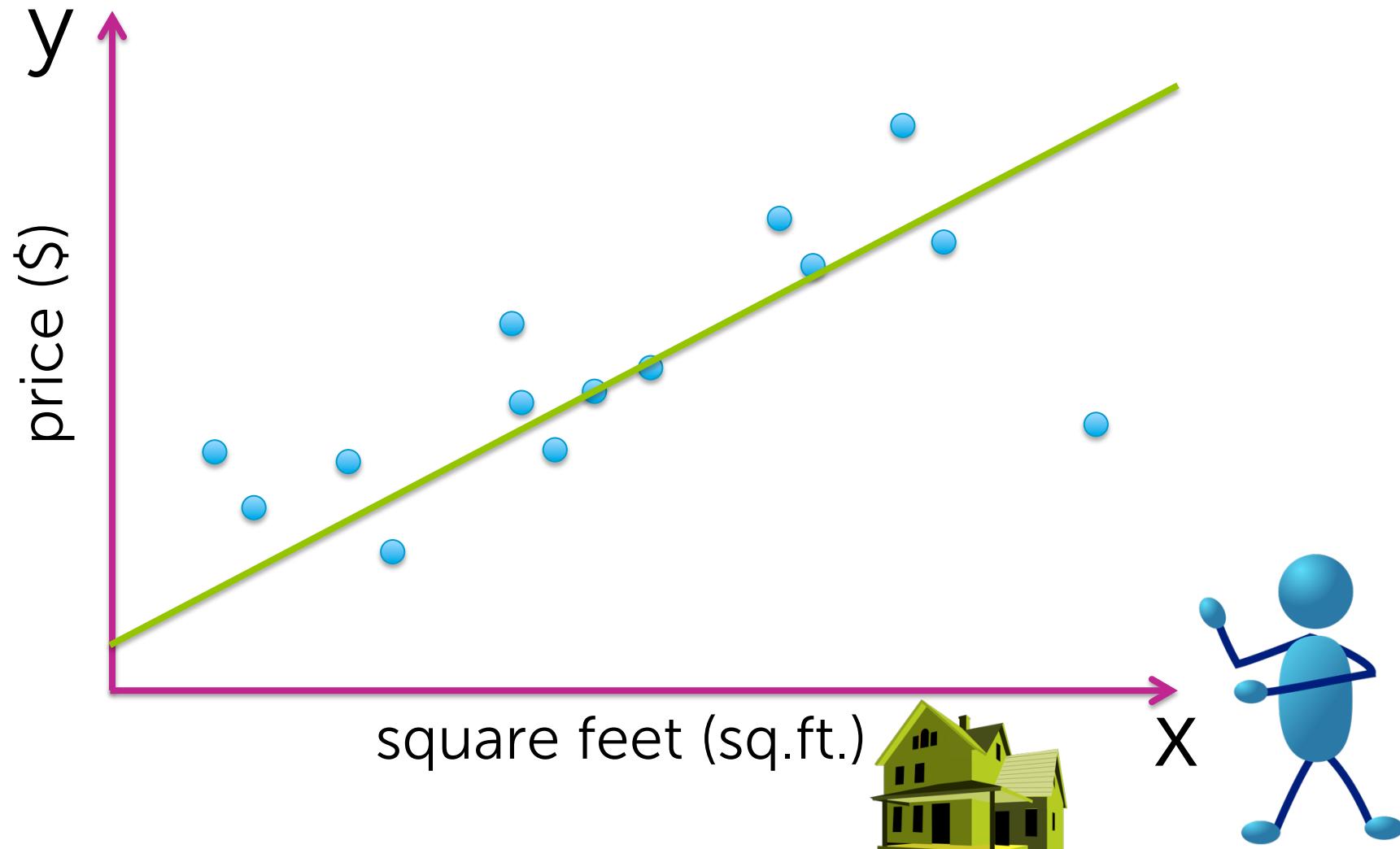
# Predicting your house price



Best guess of your  
house price:  
 $\hat{y} = \hat{w}_0 + \hat{w}_1 \text{sq.ft.}_{\text{your house}}$

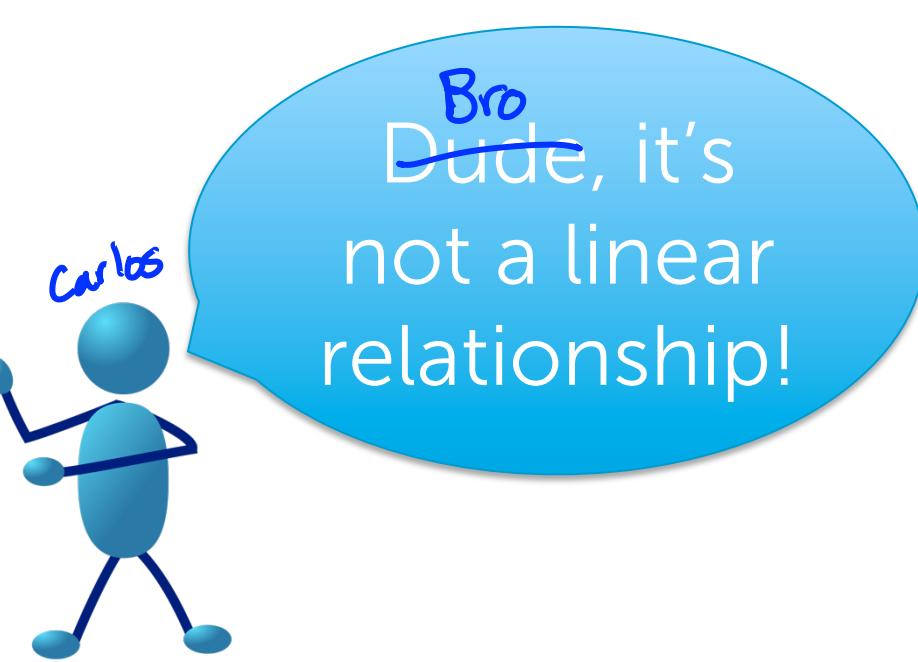
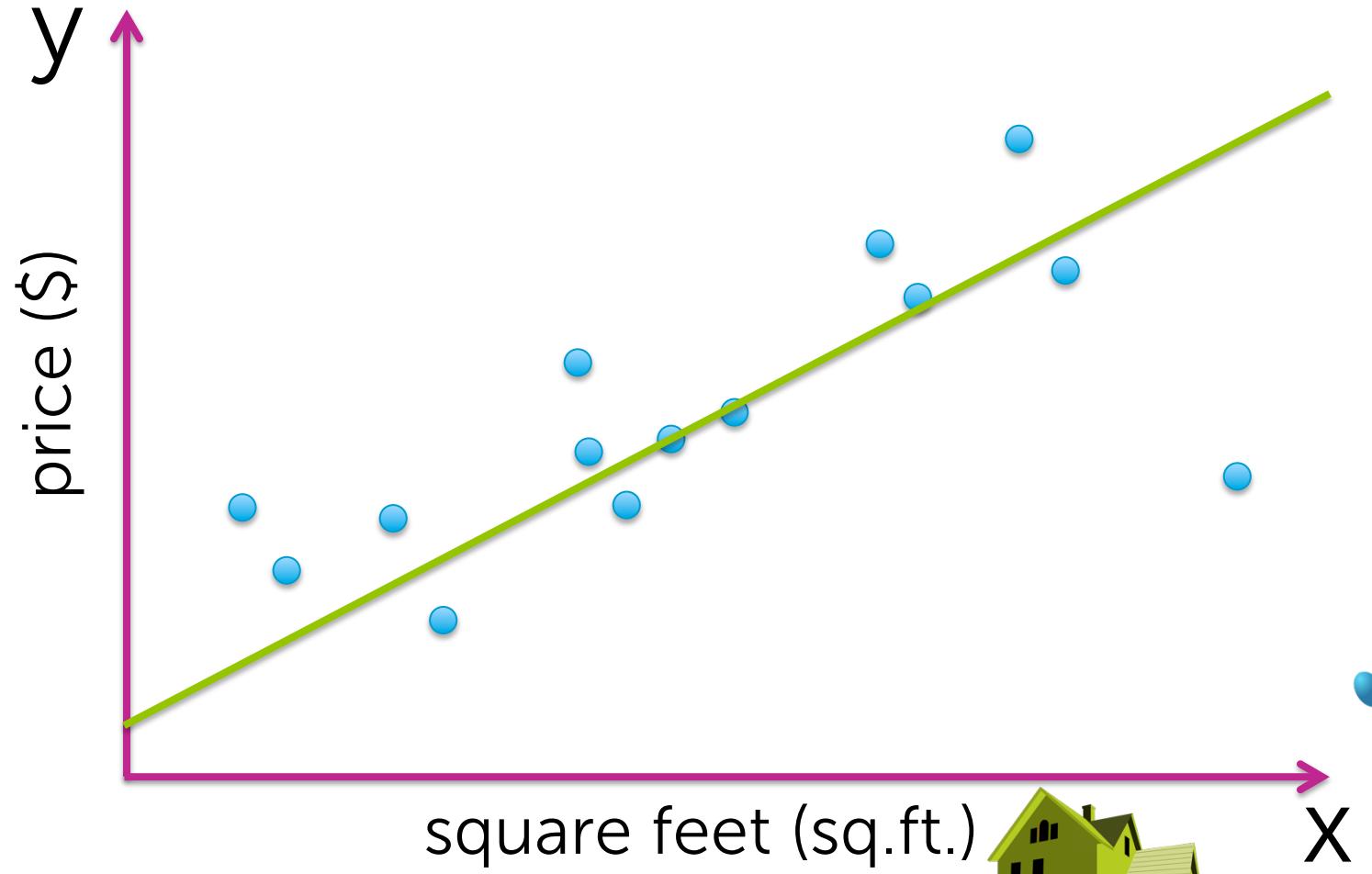
# Adding higher order effects

# Fit data with a line or ... ?

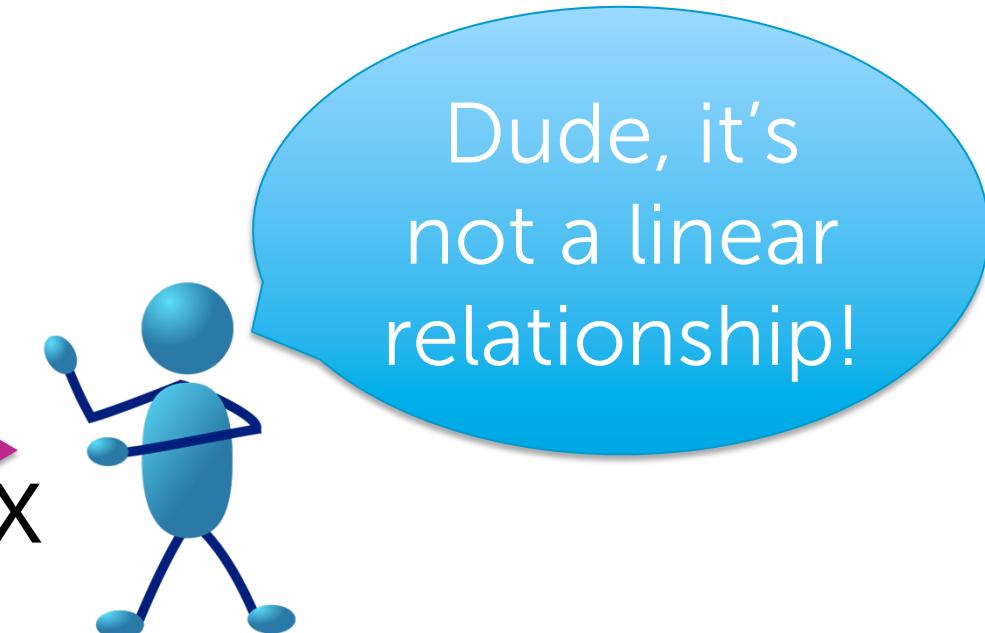
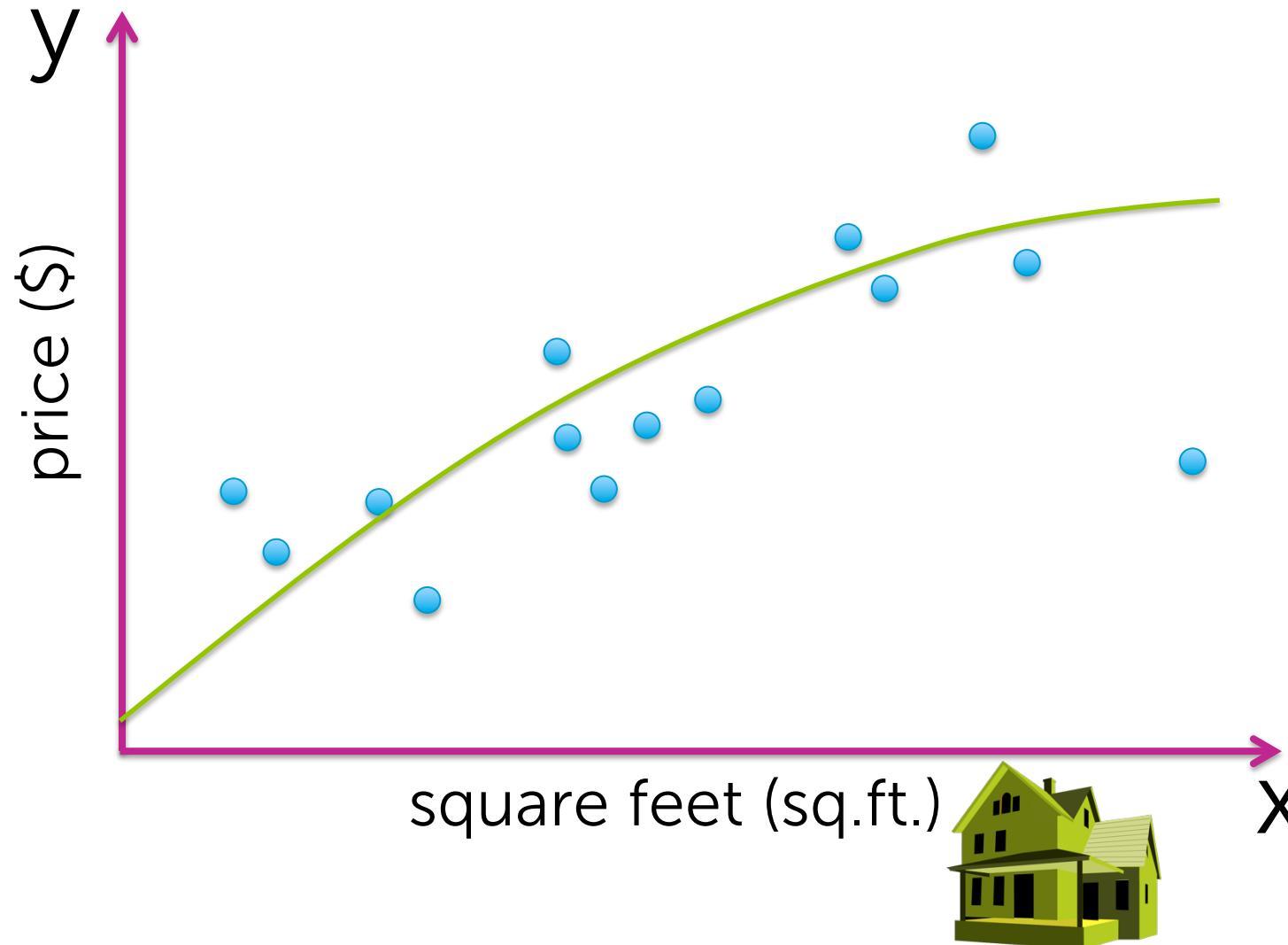


You show  
your friend  
your analysis

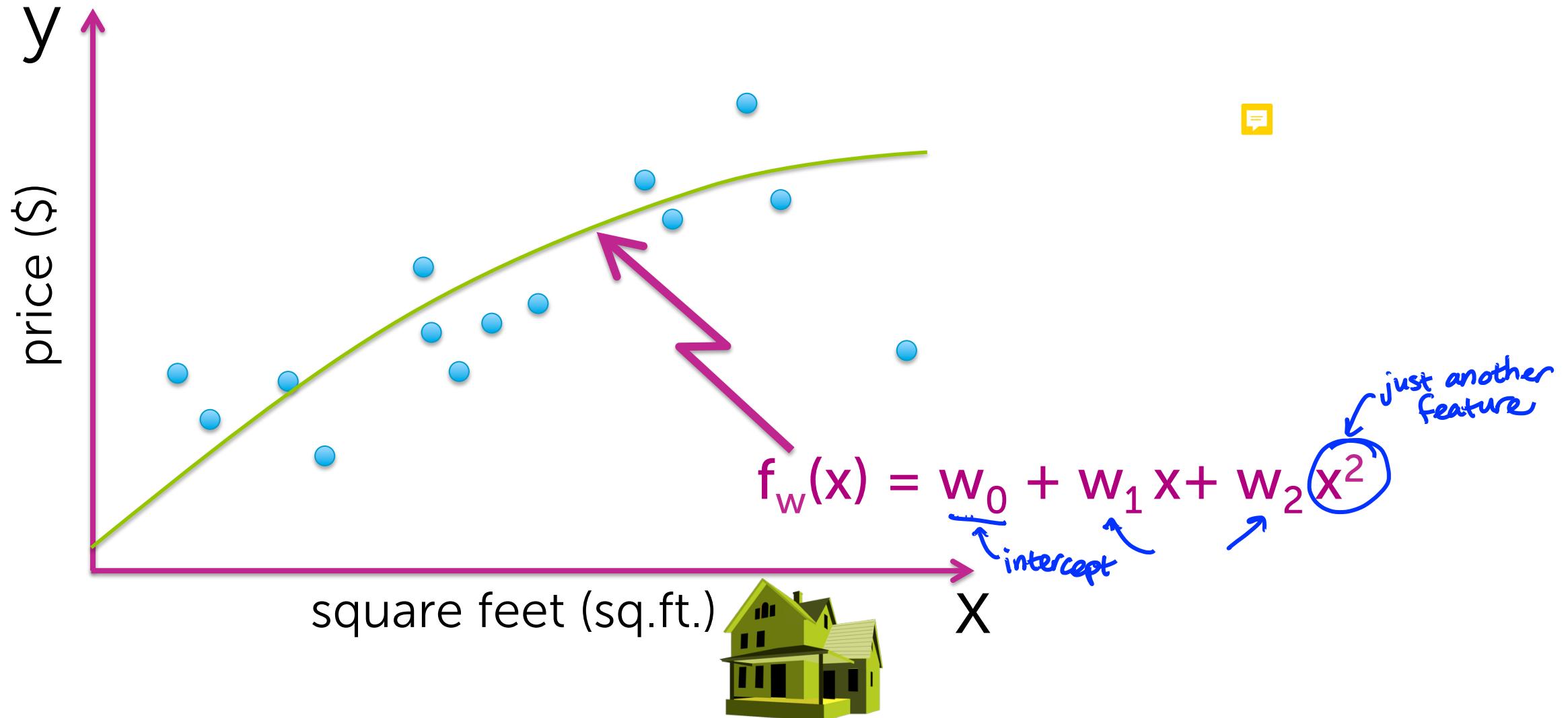
# Fit data with a line or ... ?



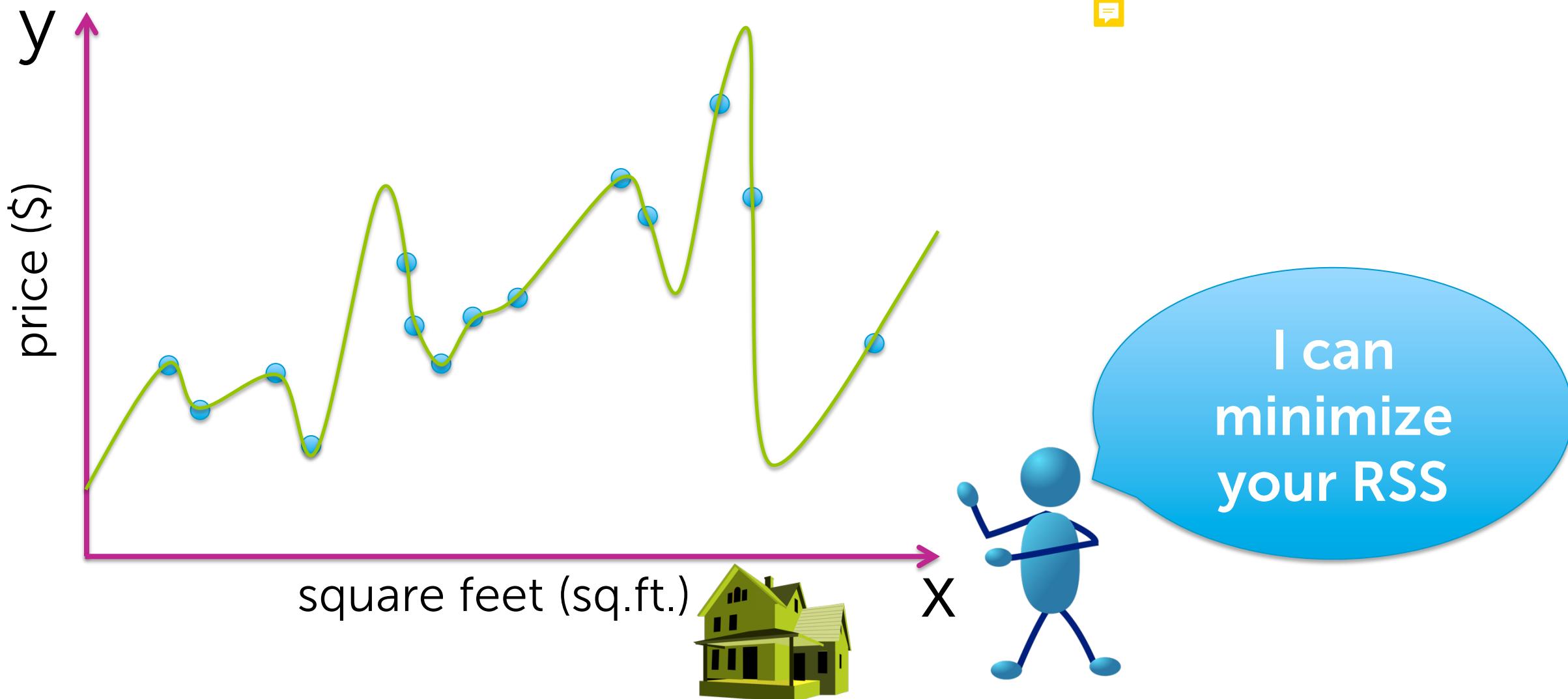
# What about a quadratic function?



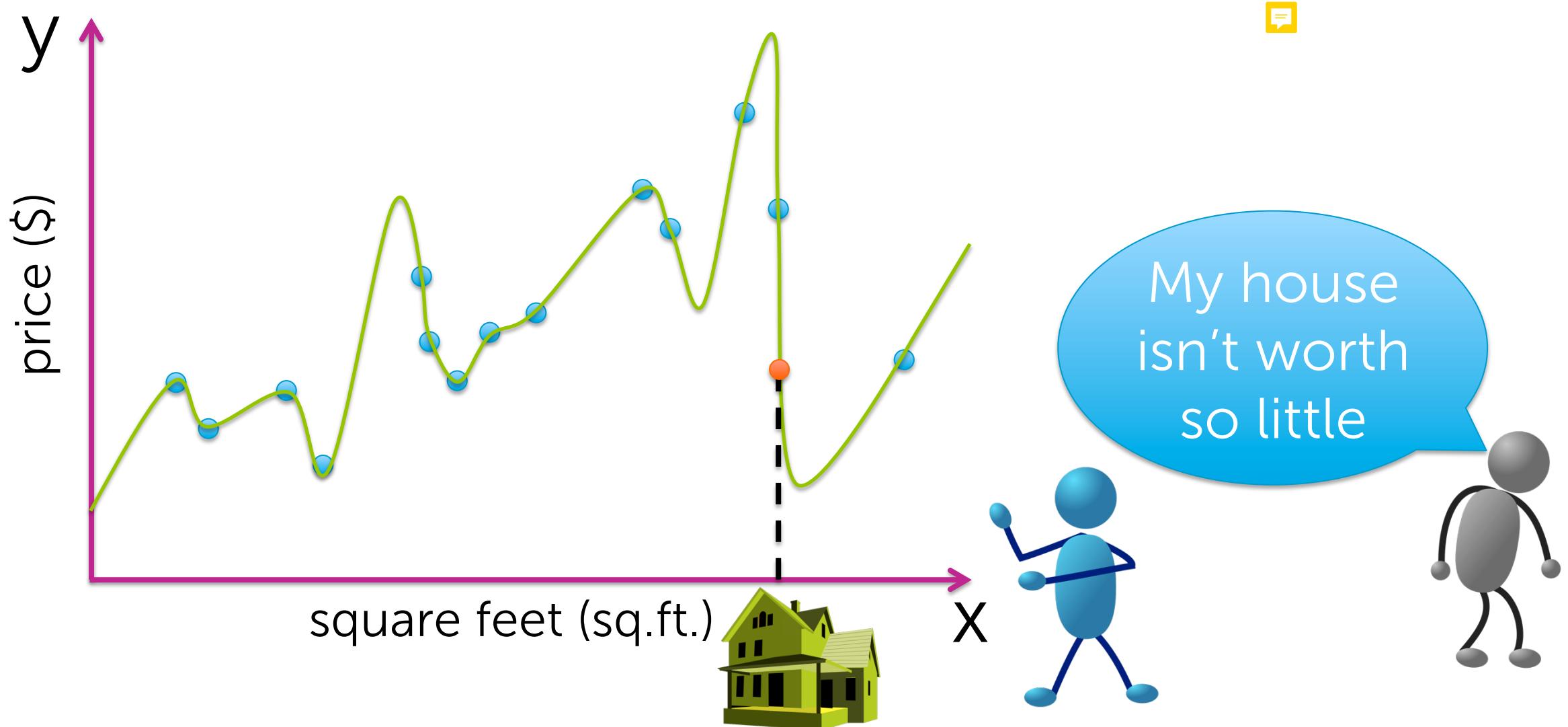
# What about a quadratic function?



# Even higher order polynomial

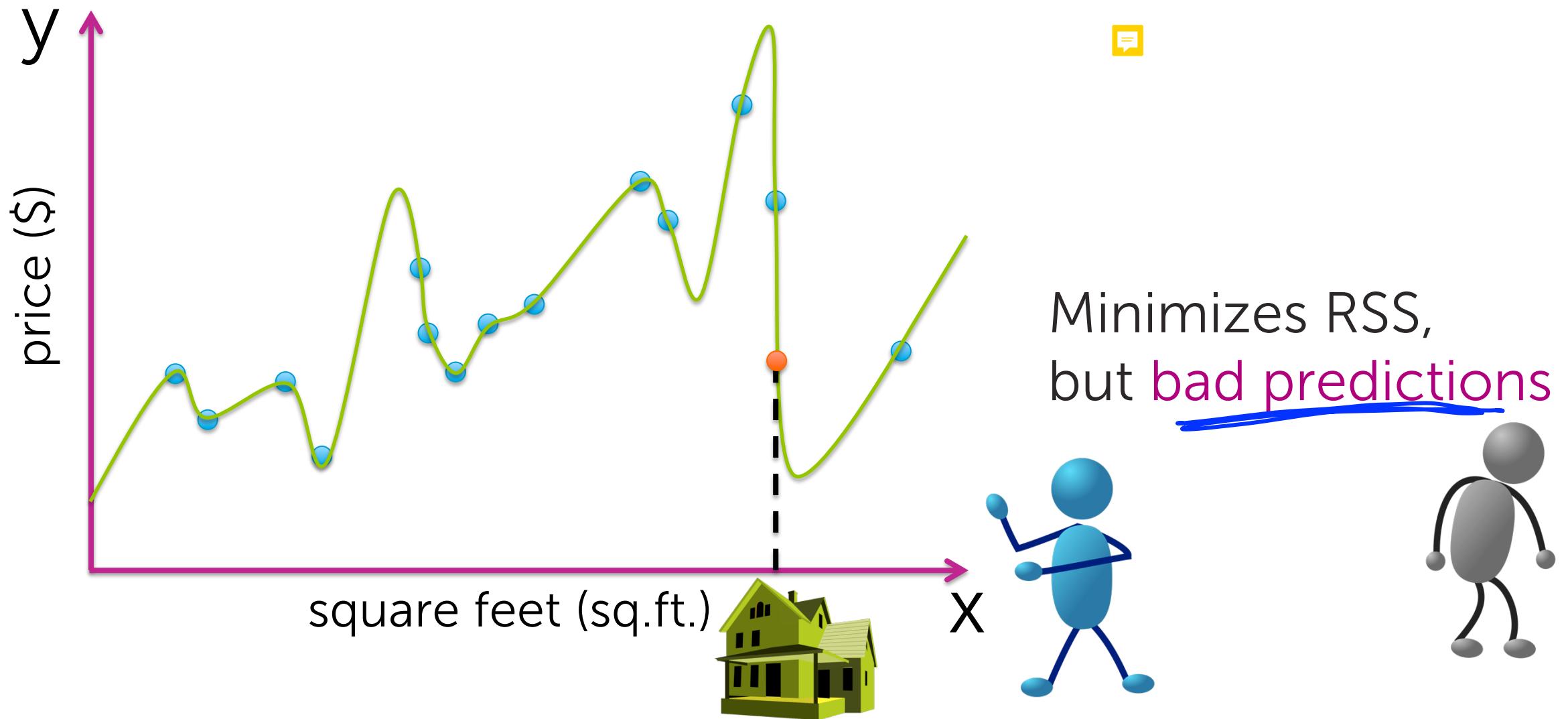


# Do you believe this fit?

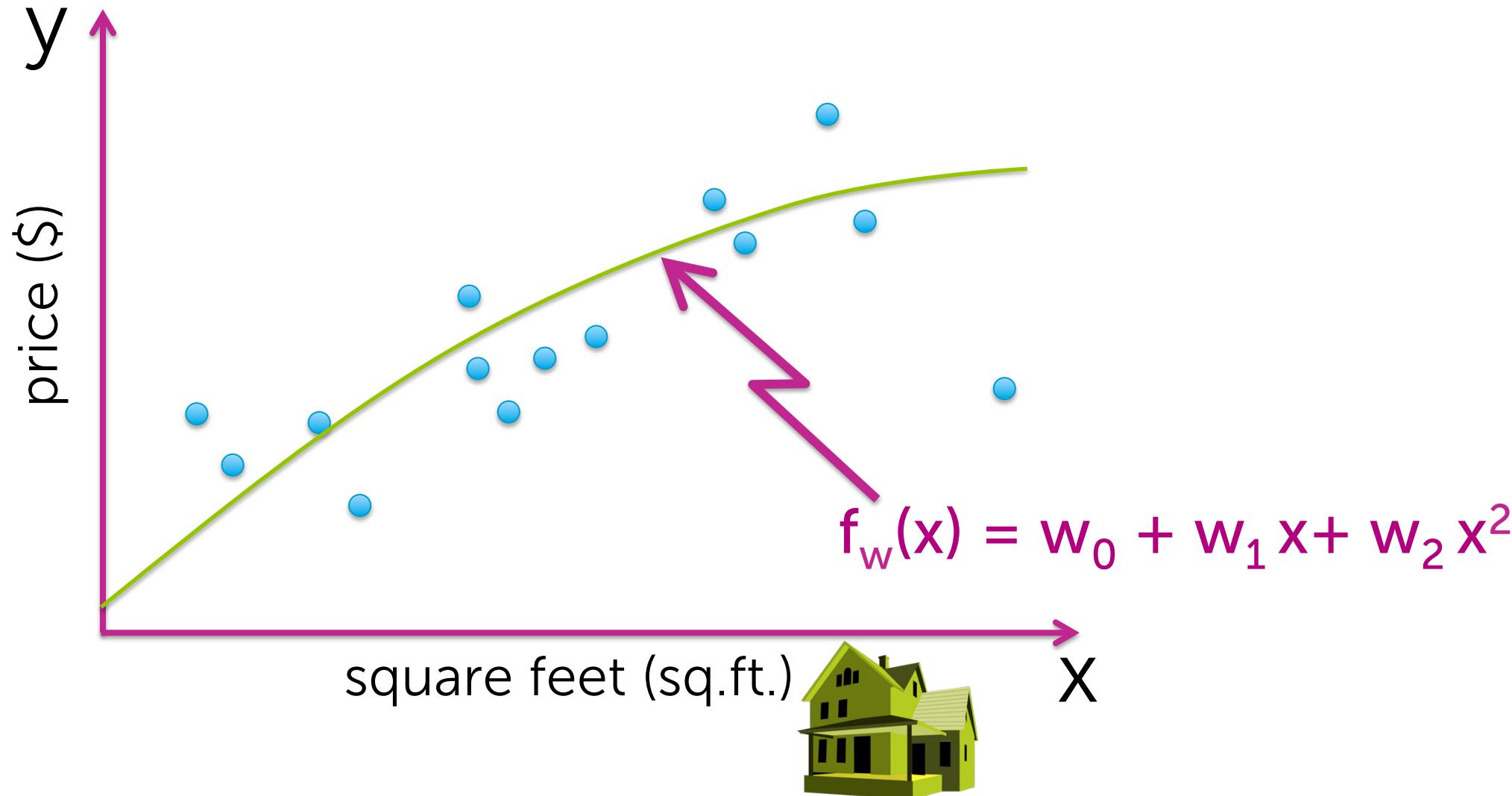


# Evaluating overfitting via training/test split

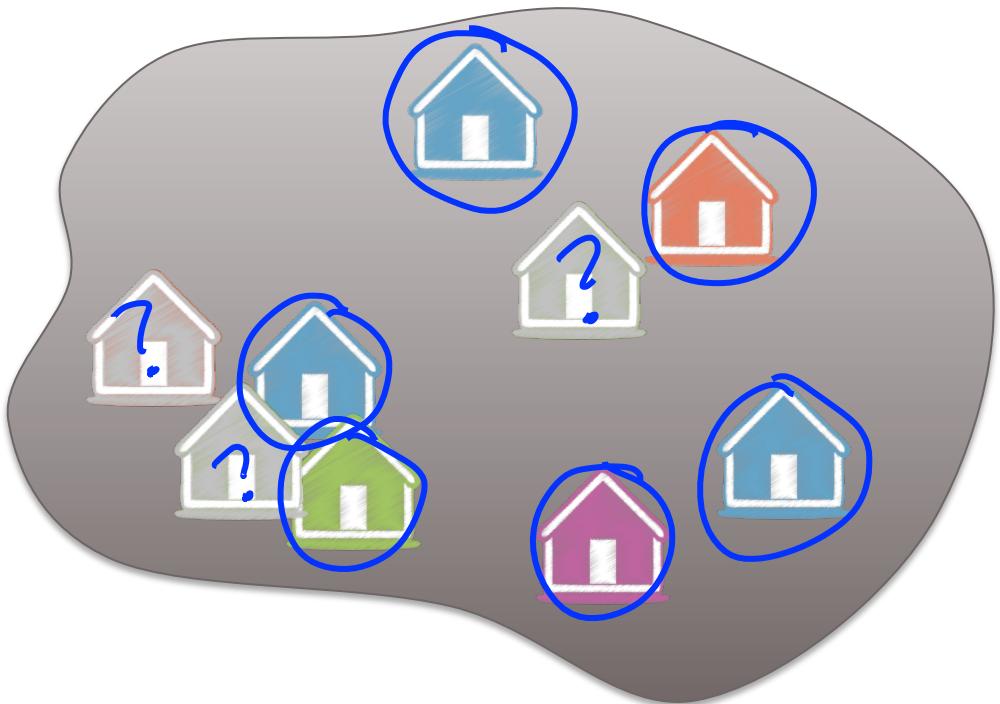
# Do you believe this fit?



# What about a quadratic function?



# How to choose model order/complexity



- Want good predictions, but can't observe future
- **Simulate predictions**
  1. Remove some houses
  2. Fit model on remaining
  3. Predict heldout houses

# Training/test split

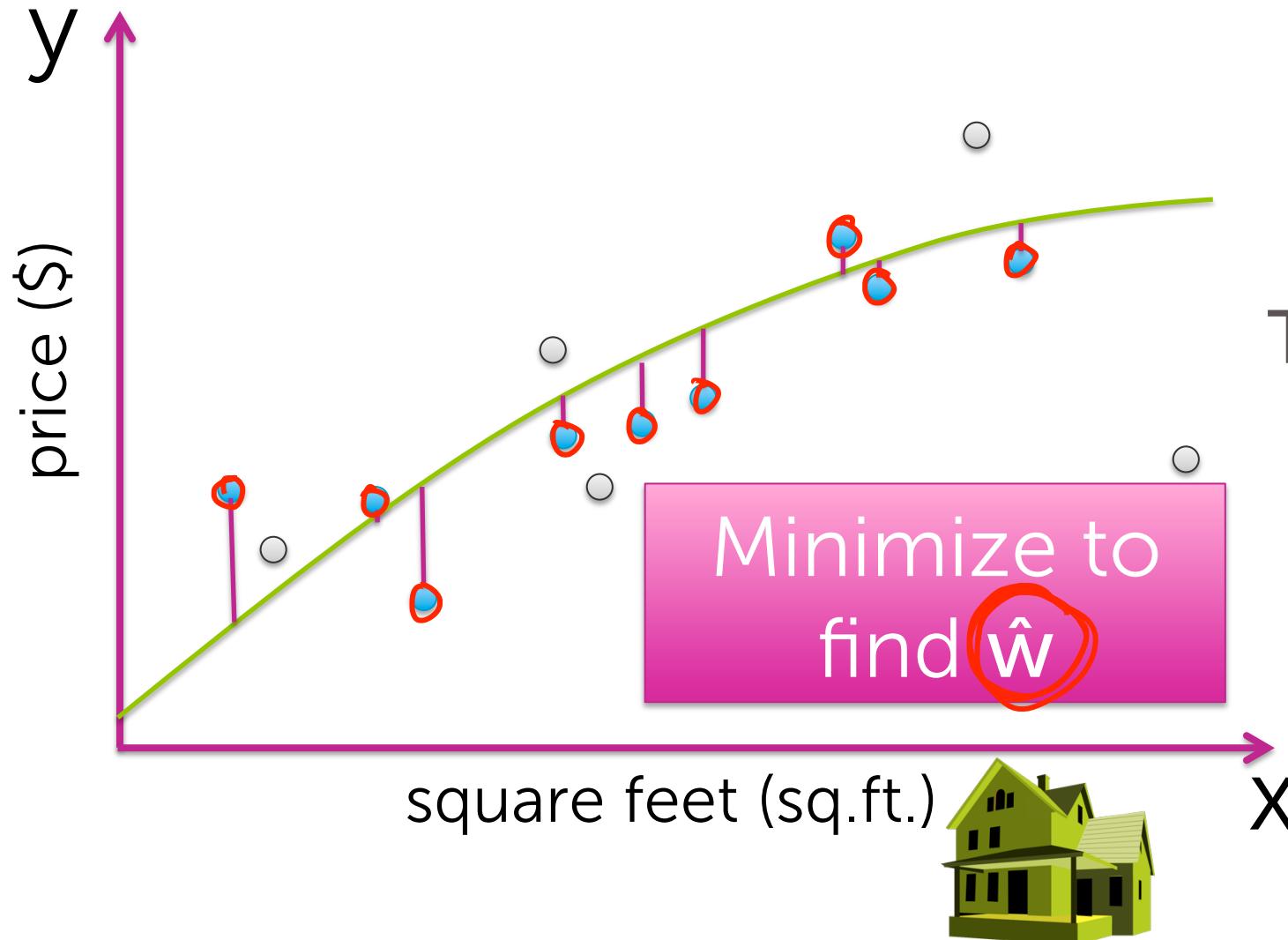


**Terminology:**

- training set
- test set

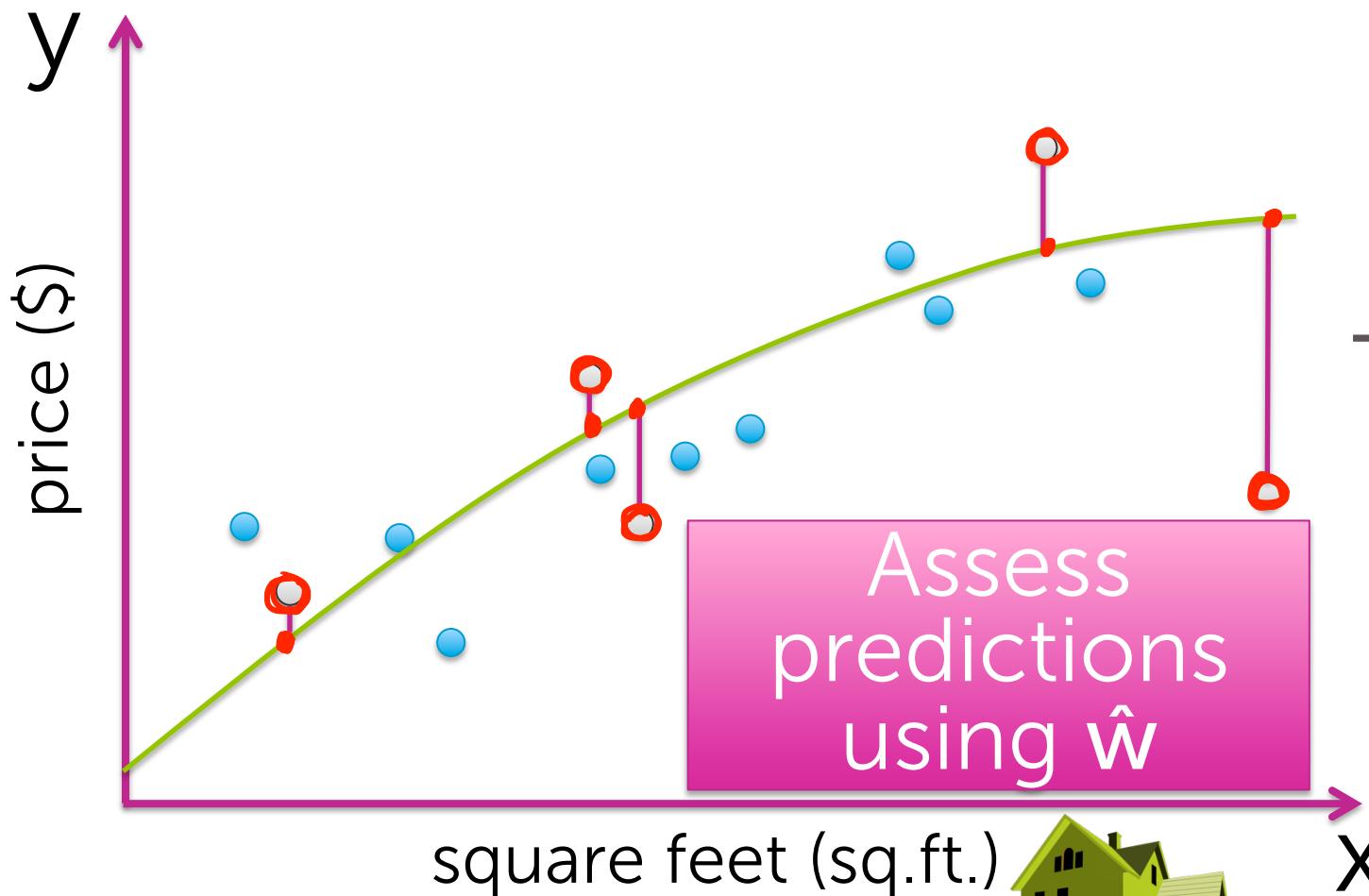


# Training error



Training error ( $w$ ) =  
$$(\$_{\text{train } 1} - f_w(\text{sq.ft.}_{\text{train } 1}))^2 + (\$_{\text{train } 2} - f_w(\text{sq.ft.}_{\text{train } 2}))^2 + (\$_{\text{train } 3} - f_w(\text{sq.ft.}_{\text{train } 3}))^2 + \dots$$
[include all training houses]

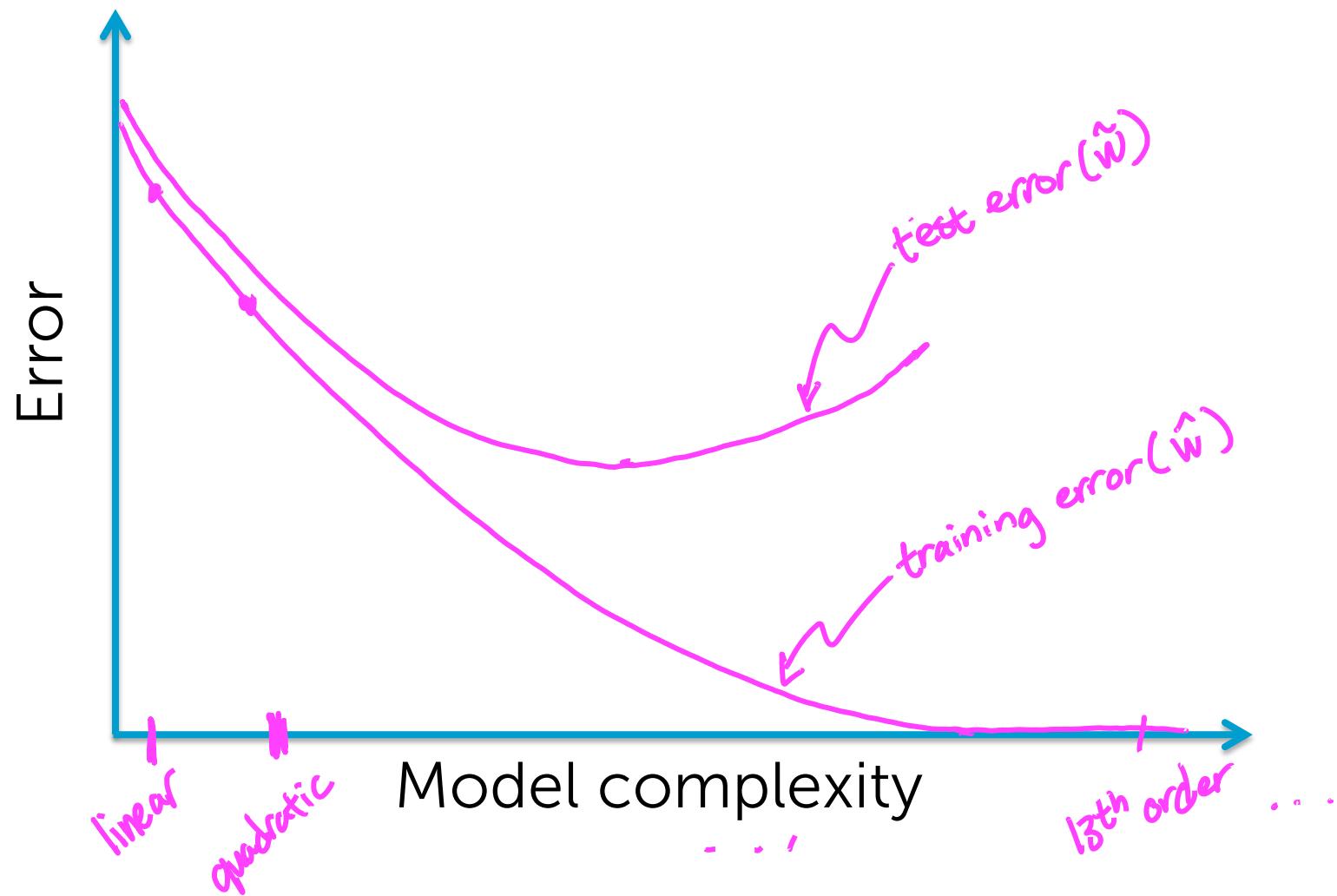
# Test error



Test error  $\hat{w} =$   
 $(\$_{\text{test } 1} - f_{\hat{w}}(\text{sq.ft.}_{\text{test } 1}))^2$   
 $+ (\$_{\text{test } 2} - f_{\hat{w}}(\text{sq.ft.}_{\text{test } 2}))^2$   
 $+ (\$_{\text{test } 3} - f_{\hat{w}}(\text{sq.ft.}_{\text{test } 3}))^2$   
+ ... [include all test houses]

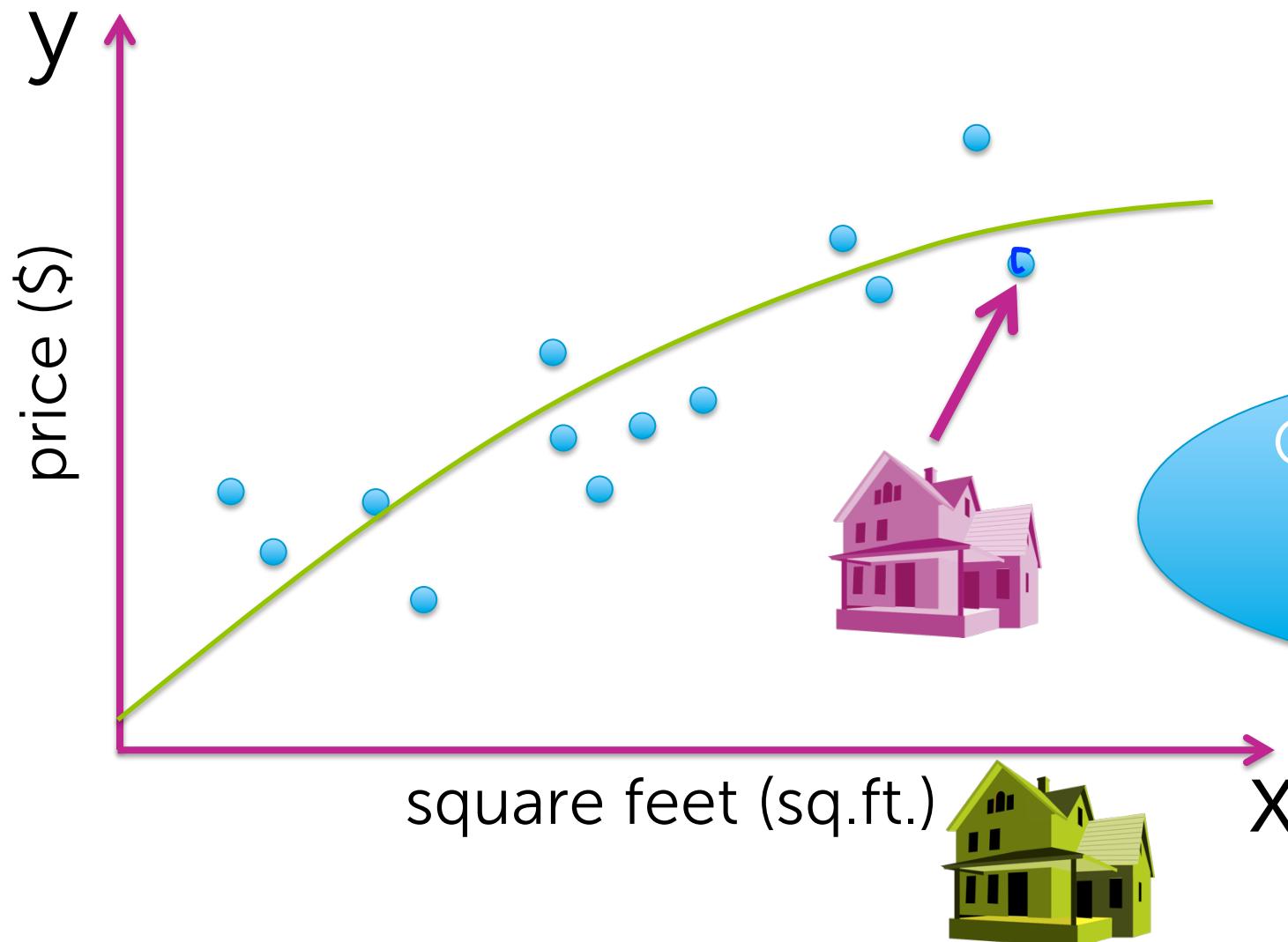


# Training/Test Curves

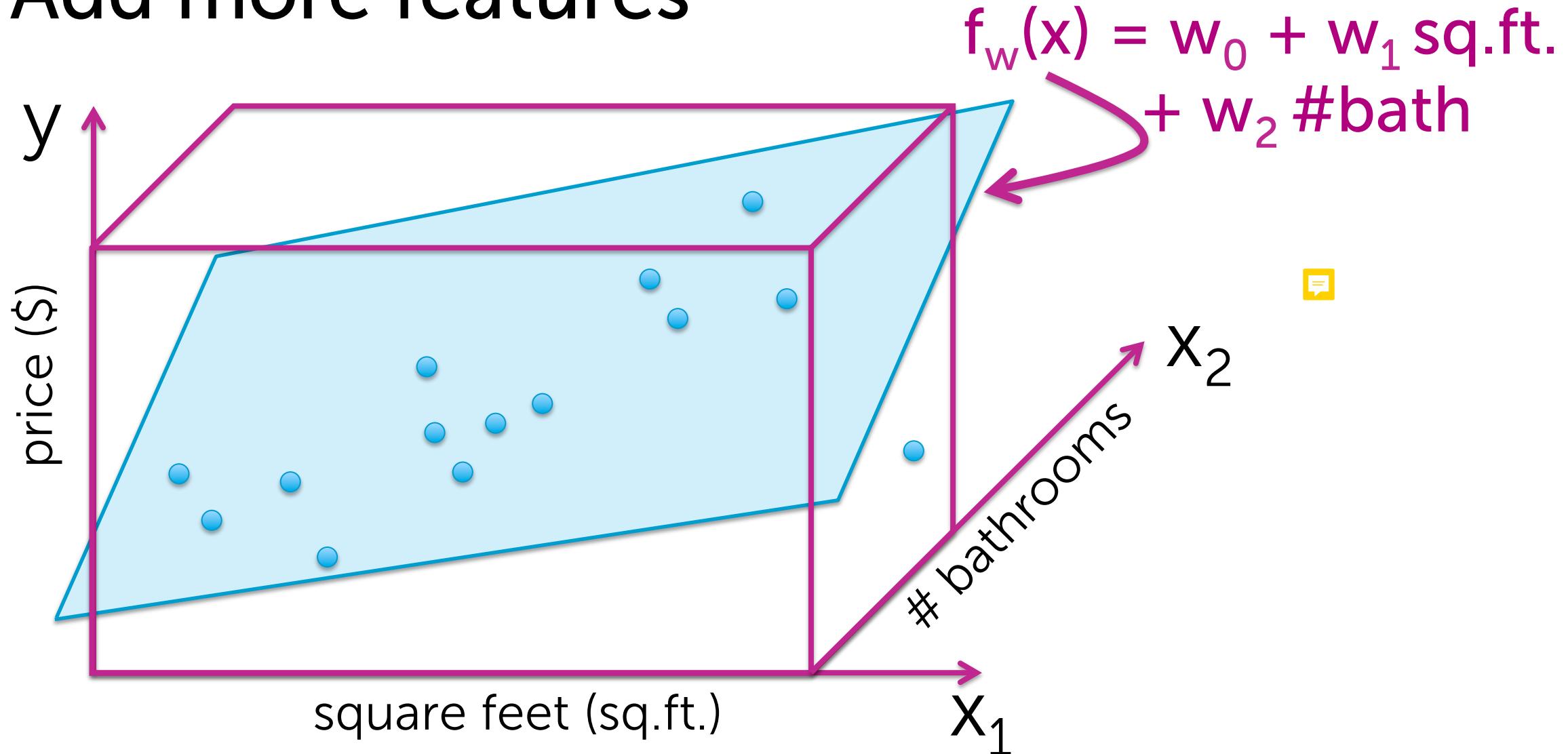


# Adding other features

# Predictions just based on house size



# Add more features

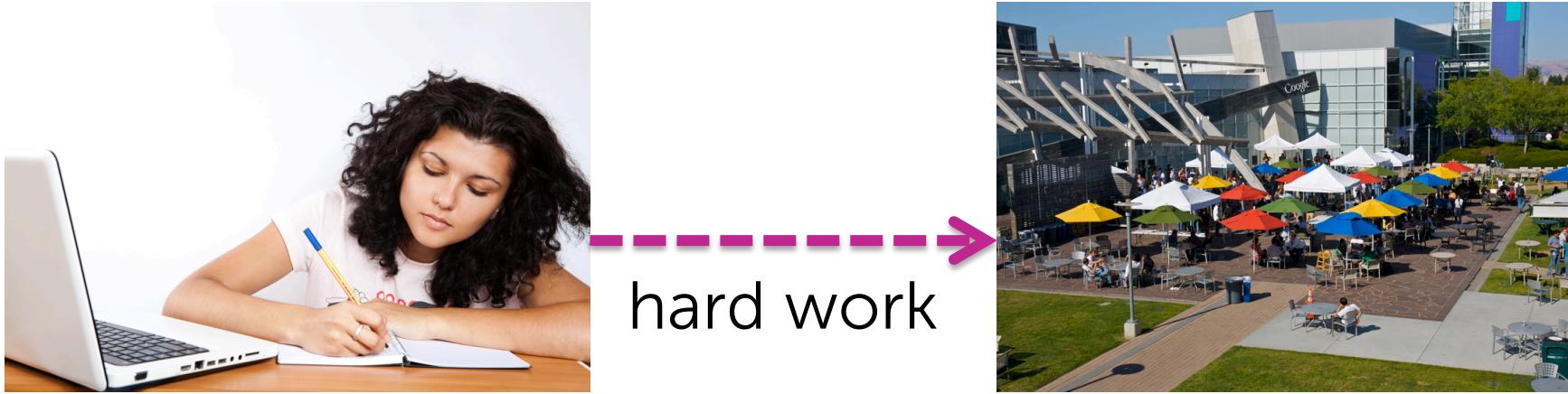


# How many features to use?

- Possible choices:
  - Square feet
  - # bathrooms
  - # bedrooms
  - Lot size
  - Year built
  - ...
- **See Regression Course!**

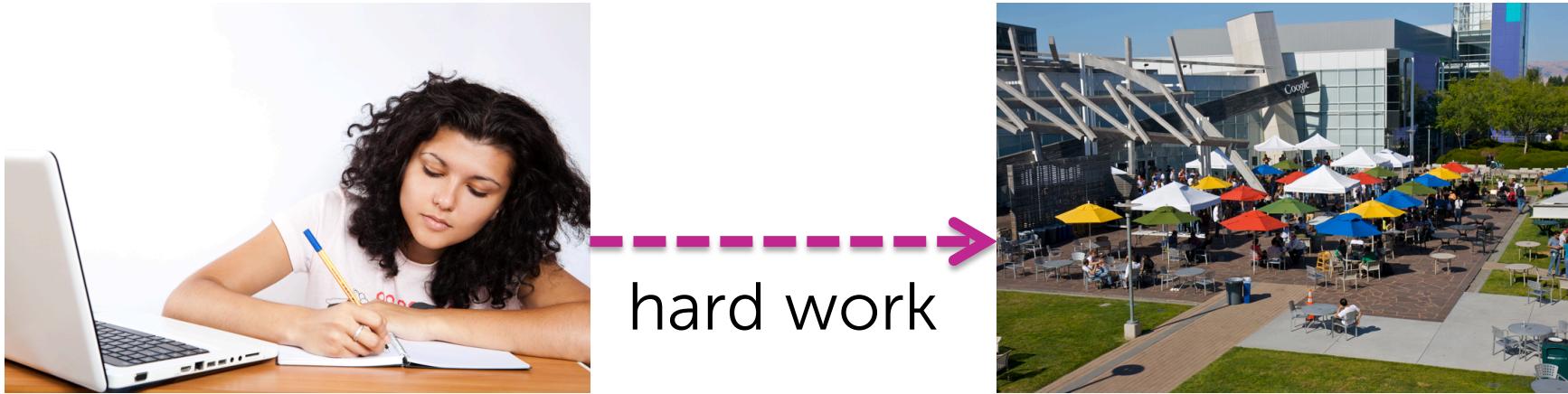
# Other regression examples

# Salary after ML specialization



- How much will your salary be? ( $y = \text{\$\$\$}$ )
- Depends on  $x = \text{performance in courses, quality of capstone project, \# of forum responses, ...}$

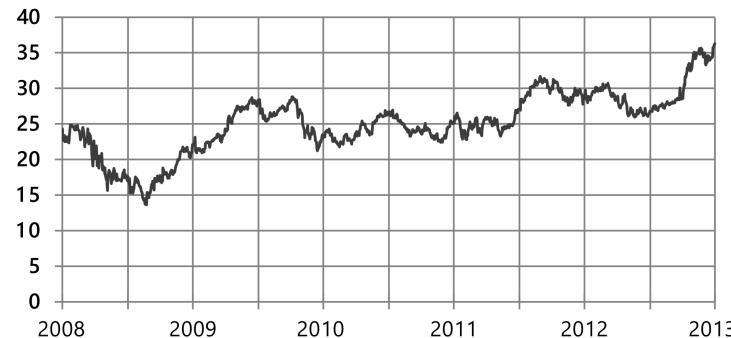
# Salary after ML specialization


$$\hat{y} = \hat{w}_0 + \hat{w}_1 \text{performance} + \hat{w}_2 \text{capstone} + \hat{w}_3 \text{forum}$$

informed by other students who completed specialization

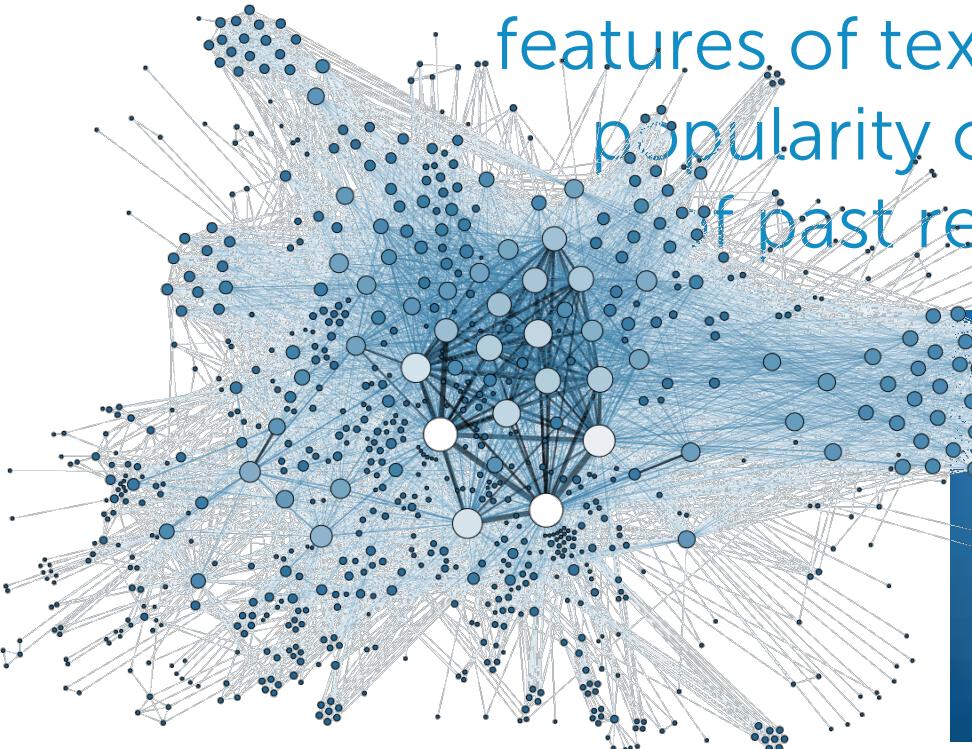
# Stock prediction

- Predict the price of a stock
- Depends on
  - Recent history of stock price
  - News events
  - Related commodities



# Tweet popularity

- How many people will retweet your tweet?
- Depends on # followers,  
# of followers of followers,  
features of text tweeted,  
popularity of hashtag,  
of past retweets,...



# Smart houses

- Smart houses have many distributed sensors
- What's the temperature at your desk? (no sensor)
  - Learn spatial function to predict temp
- Also depends on
  - Thermostat setting
  - Blinds open/closed or window tint
  - Vents
  - Temperature outside
  - Time of day



# Summary for regression

# What you can do now...

- Describe the input (features) and output (real-valued predictions) of a regression model
- Calculate a goodness-of-fit metric (e.g., RSS)
- Estimate model parameters by minimizing RSS (algorithms to come...)
- Exploit the estimated model to form predictions
- Perform a training/test split of the data
- Analyze performance of various regression models in terms of test error
- Use test error to avoid overfitting when selecting amongst candidate models
- Describe a regression model using multiple features
- Describe other applications where regression is useful