

Regression: Predicting House Prices



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Predicting house prices

How much is my house worth?



How much is my house worth?

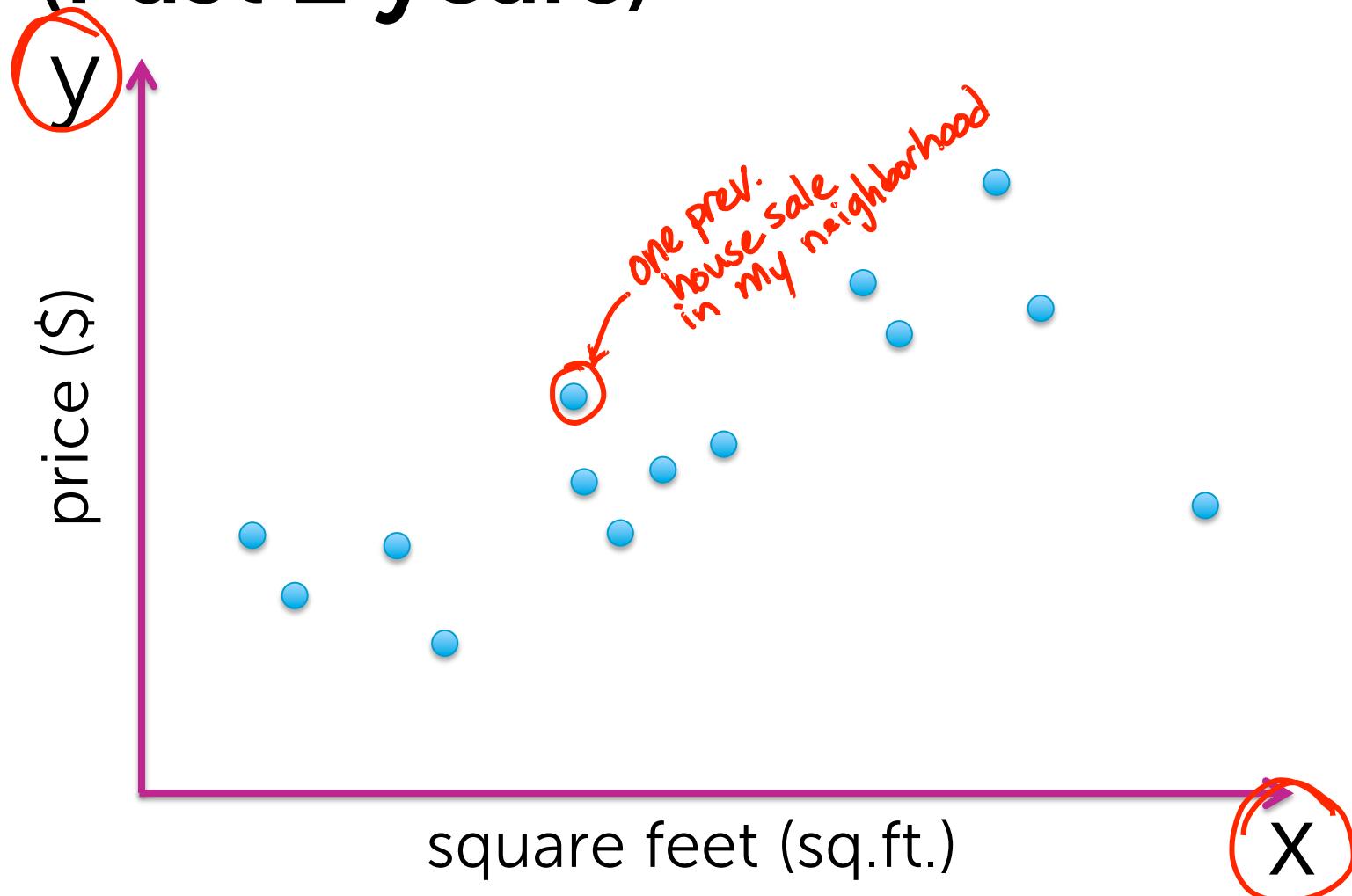


Look at recent sales in my neighborhood

- How much did they sell for?



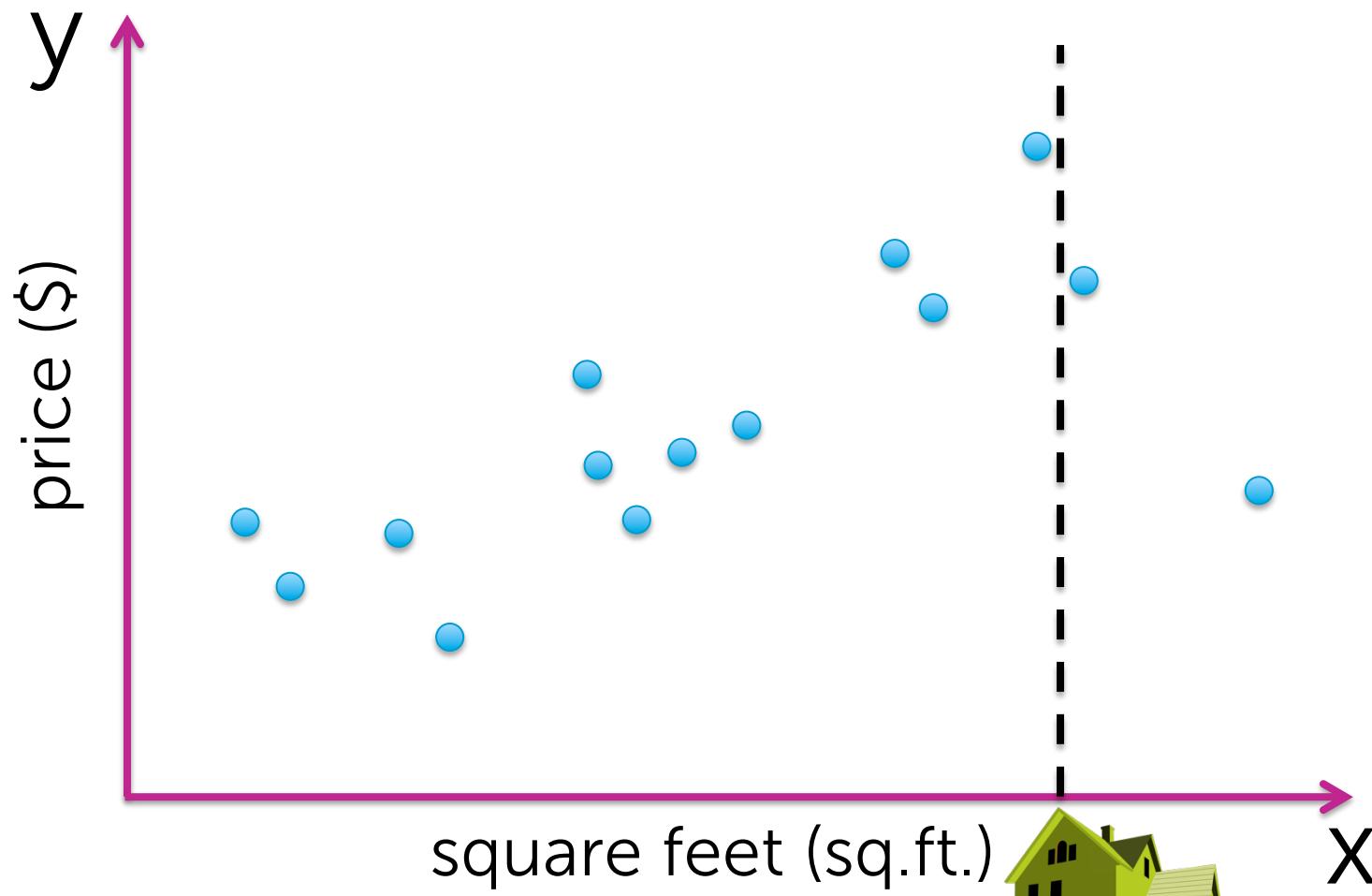
Plot recent house sales (Past 2 years)



Terminology:

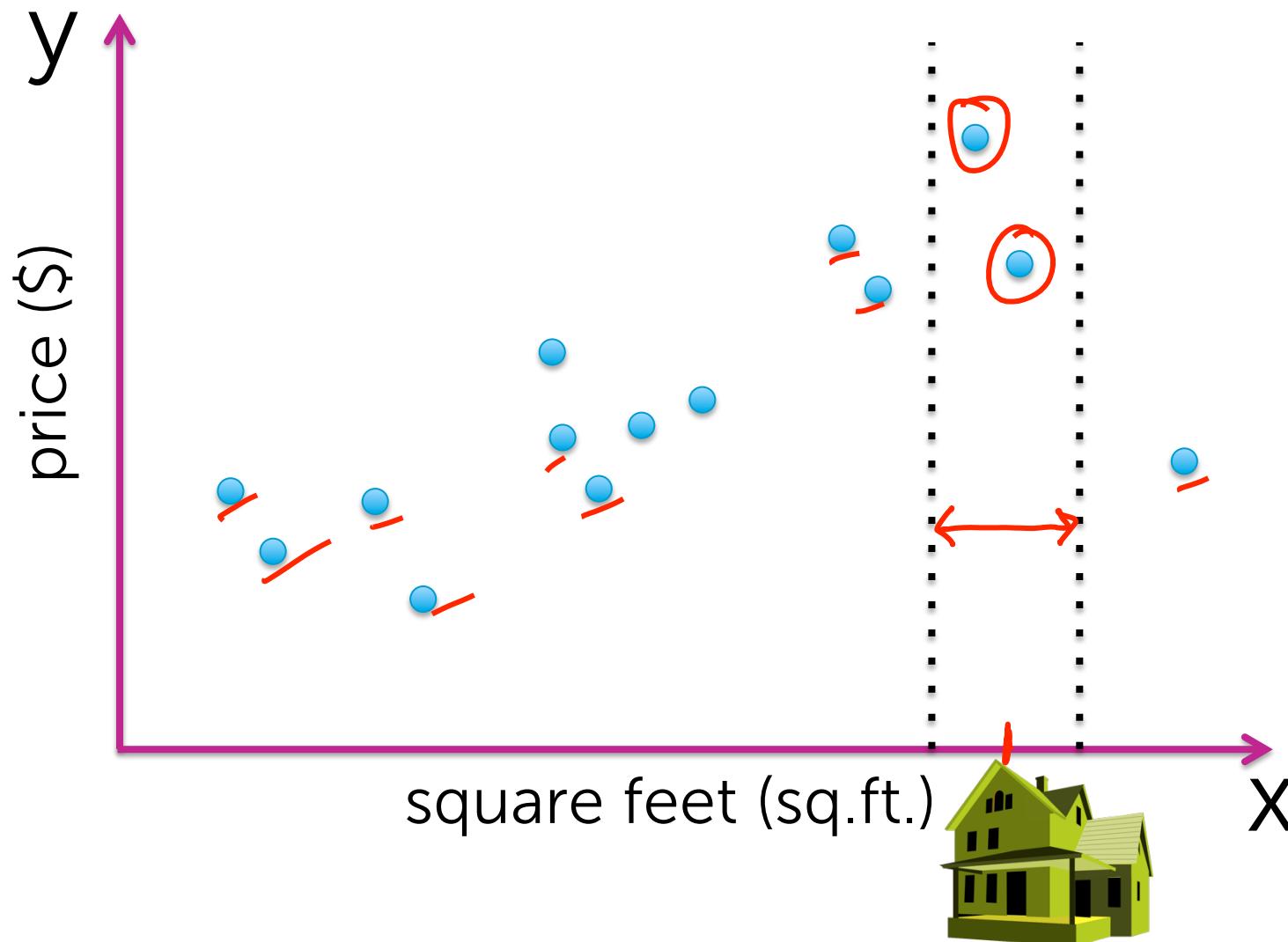
- x – feature, covariate, or predictor
- y – observation or response

Predict your house by similar houses



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

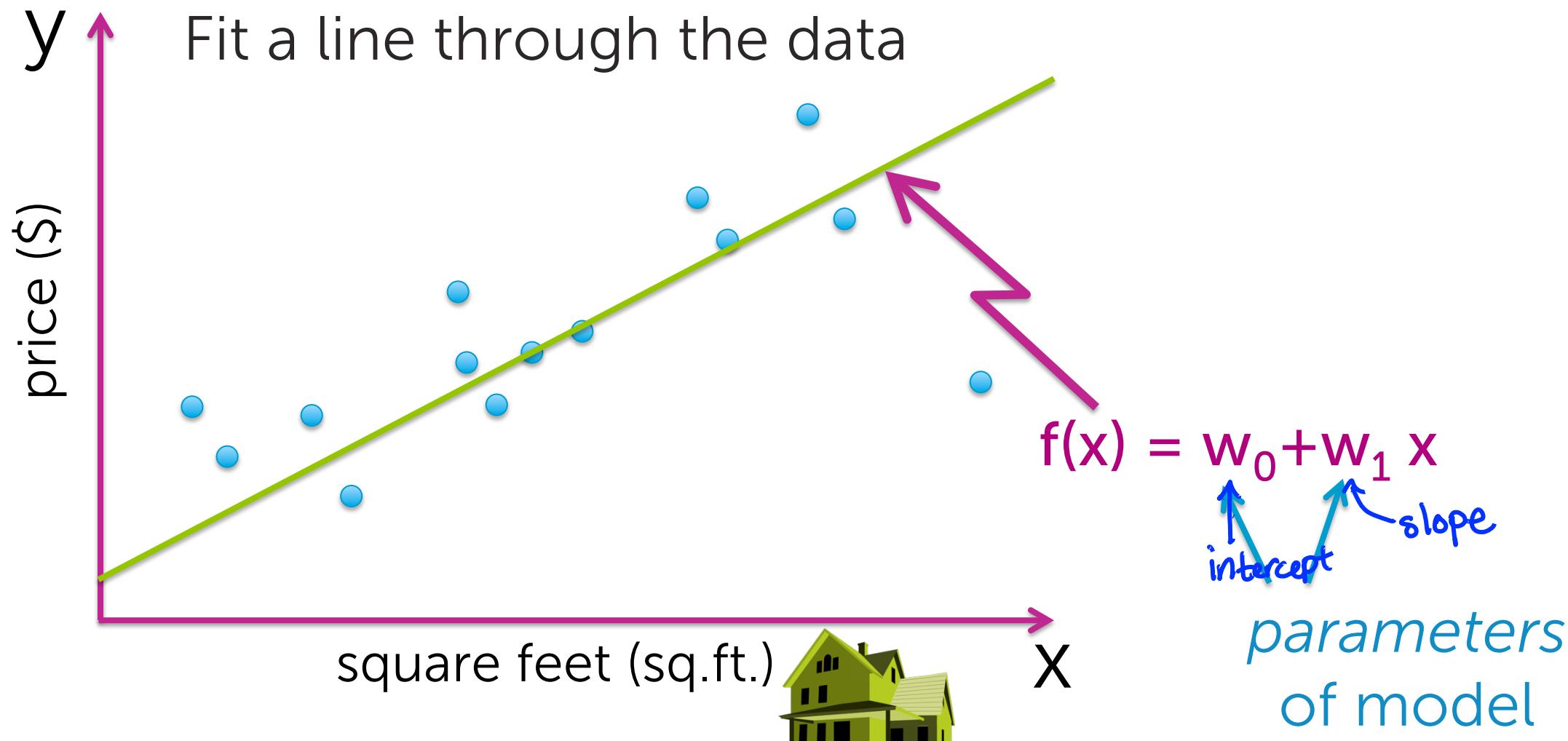
Predict your house by similar houses



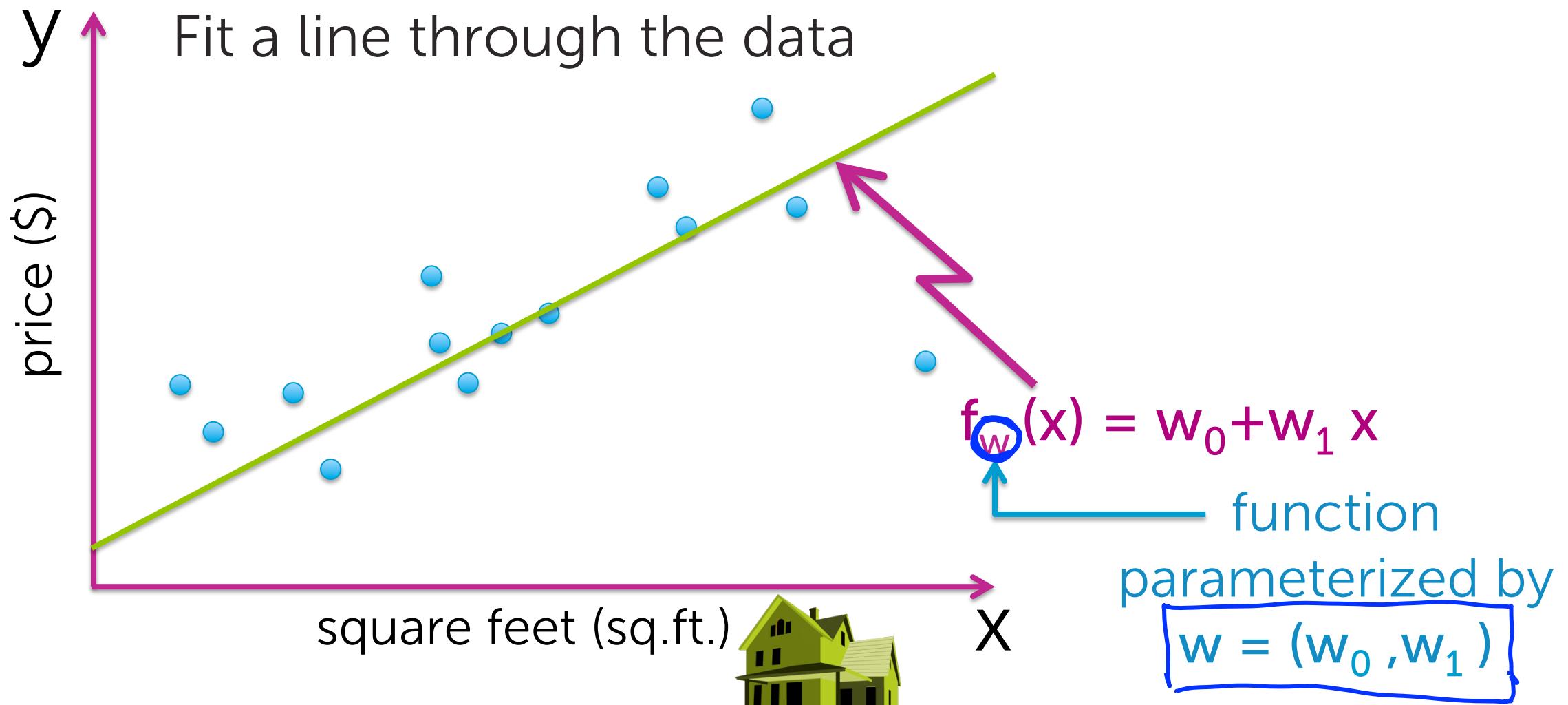
- Look at average price in range
- **Still only 2 houses!**
- Throwing out info from all other sales

Linear regression

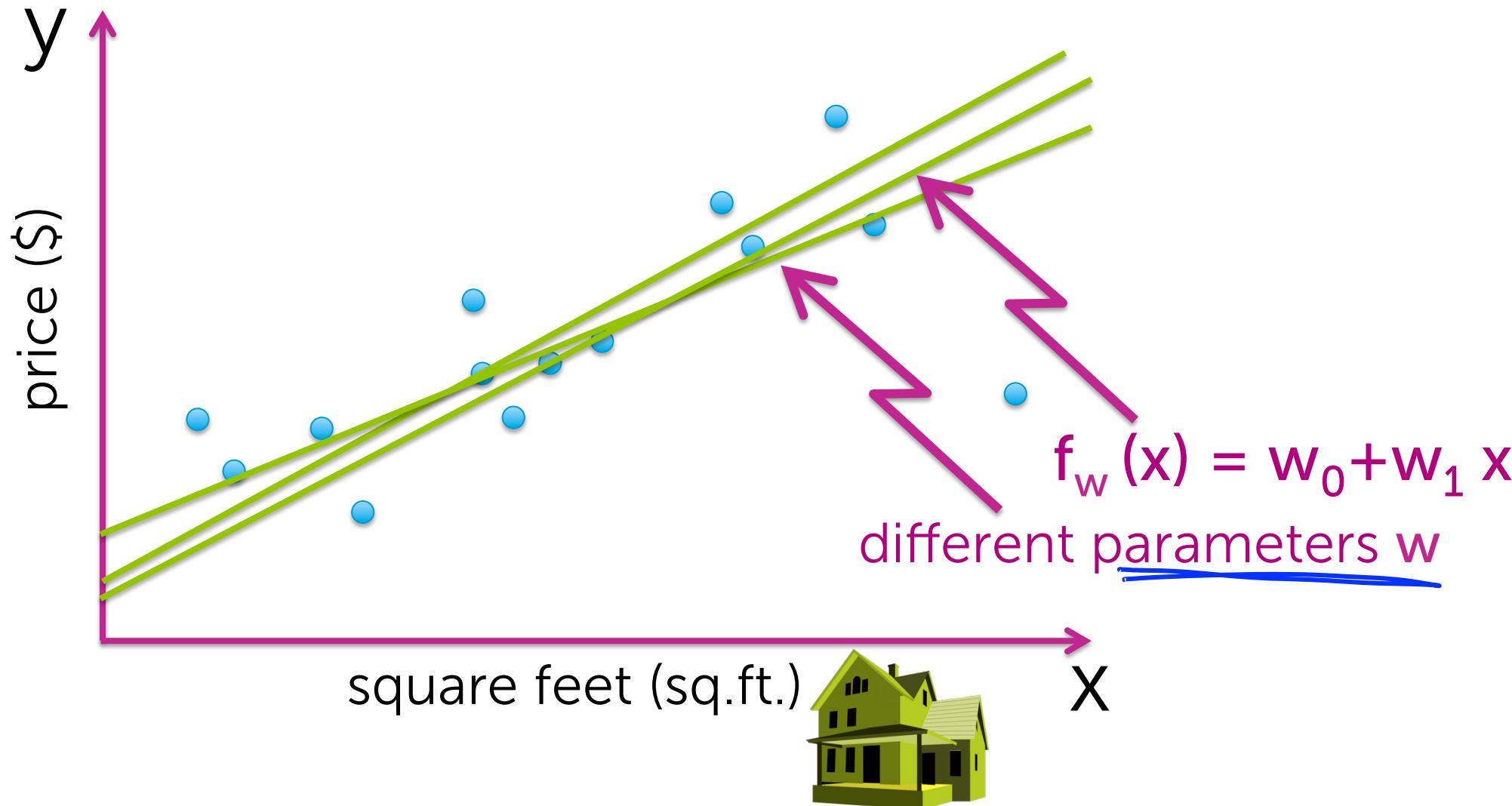
Use a **linear** regression model



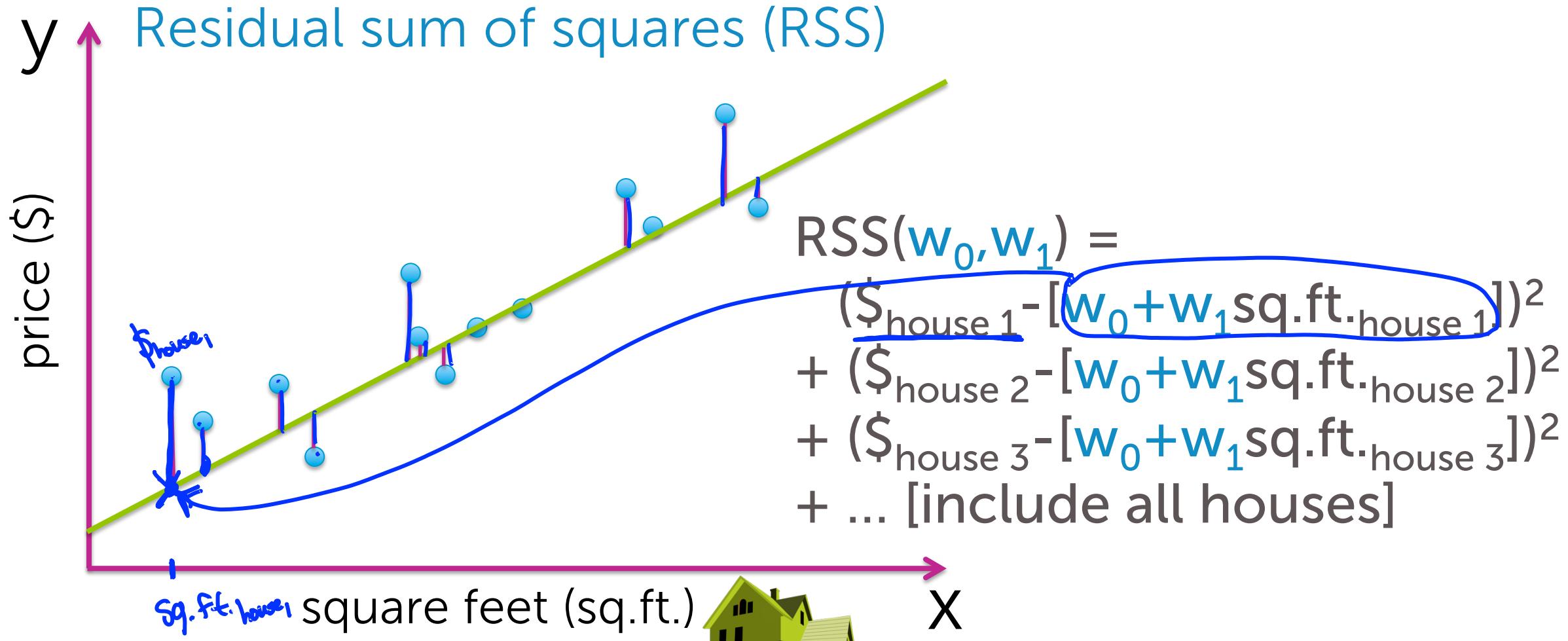
Use a **linear** regression model



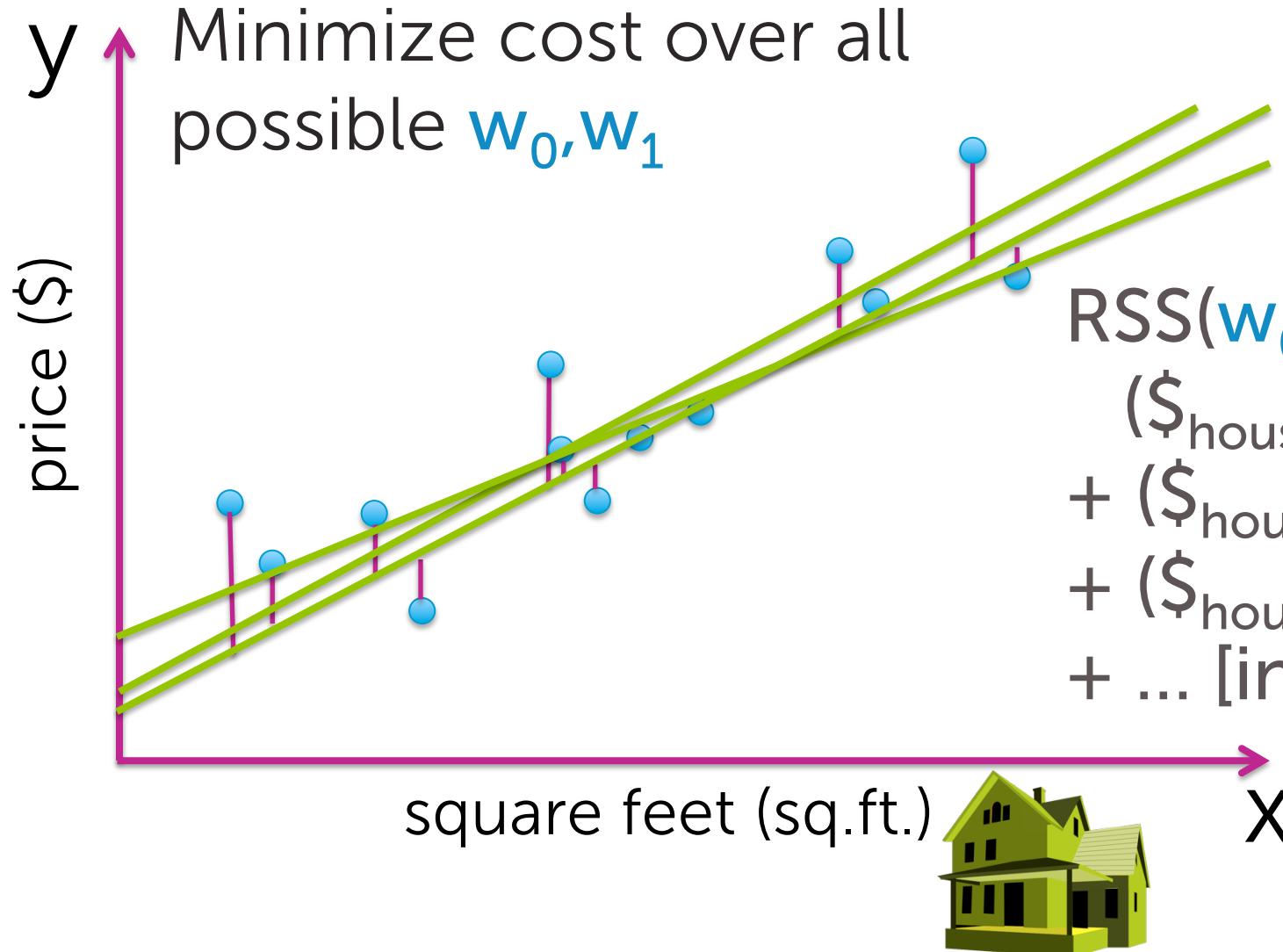
Which line?



“Cost” of using a given line



Find “best” line

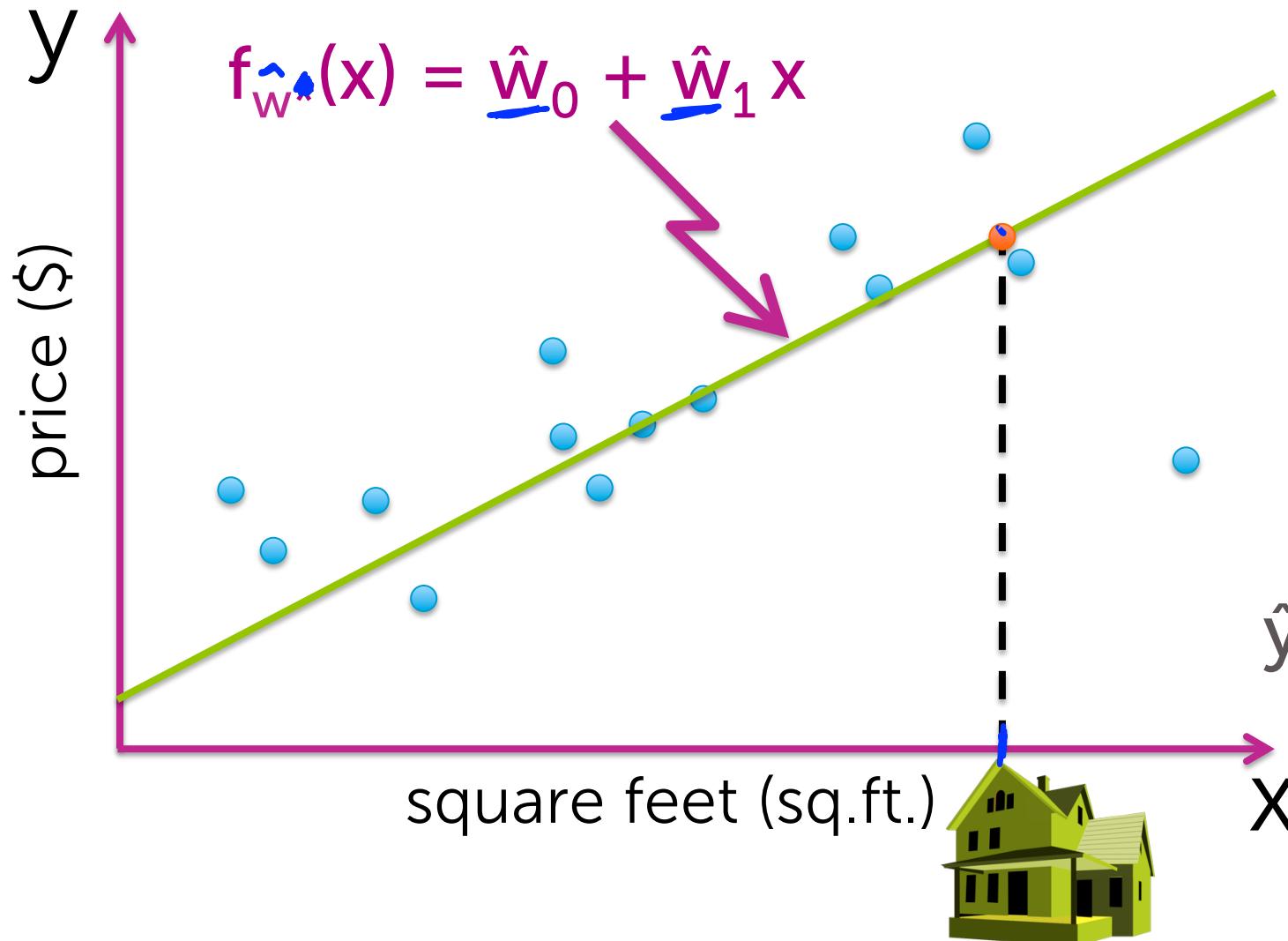


$$\begin{aligned} \text{RSS}(w_0, w_1) = & (\$_{\text{house 1}} - [w_0 + w_1 \text{sq.ft.}_{\text{house 1}}])^2 \\ & + (\$_{\text{house 2}} - [w_0 + w_1 \text{sq.ft.}_{\text{house 2}}])^2 \\ & + (\$_{\text{house 3}} - [w_0 + w_1 \text{sq.ft.}_{\text{house 3}}])^2 \\ & + \dots \text{[include all houses]}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



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

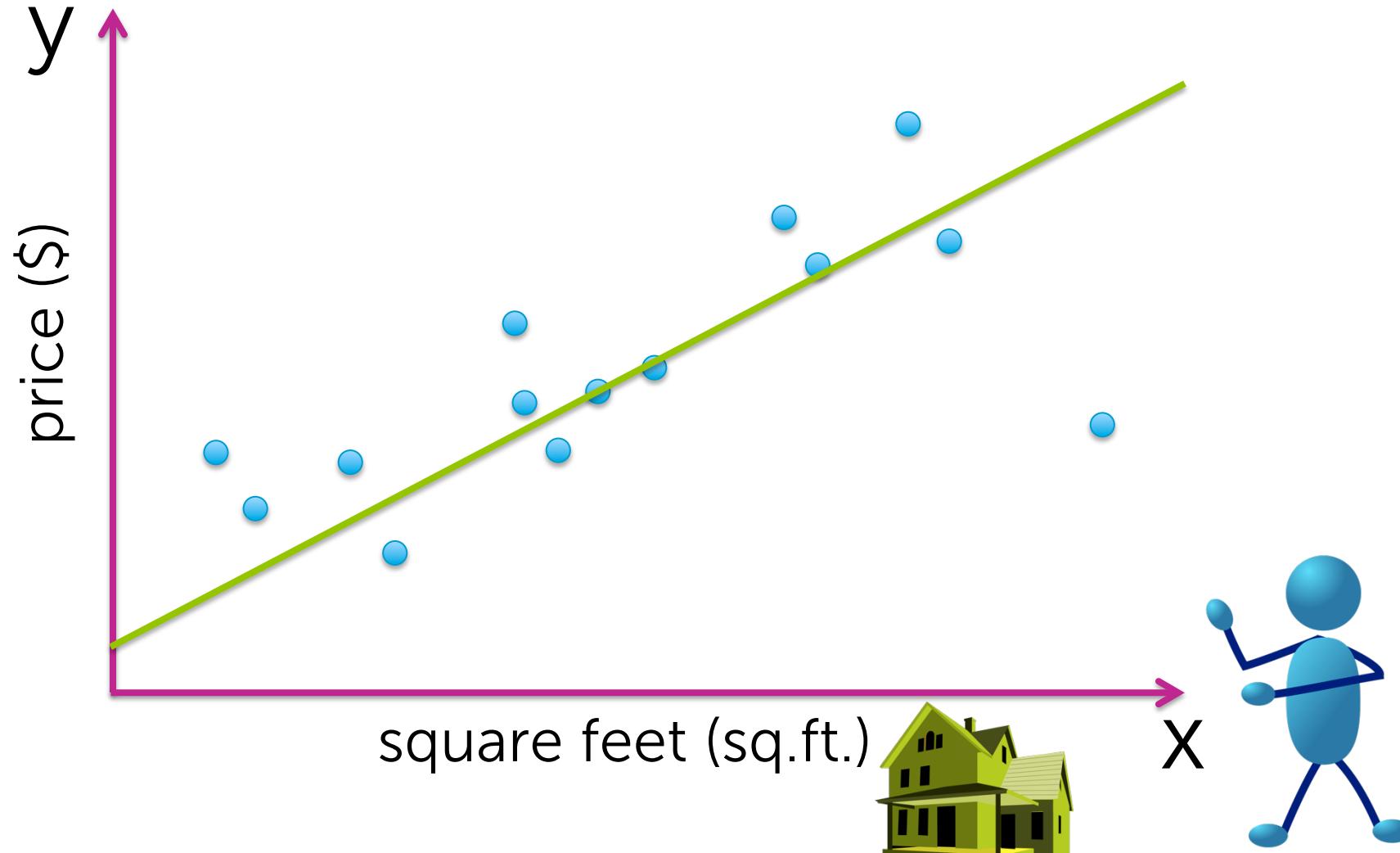
Predicting your house price



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

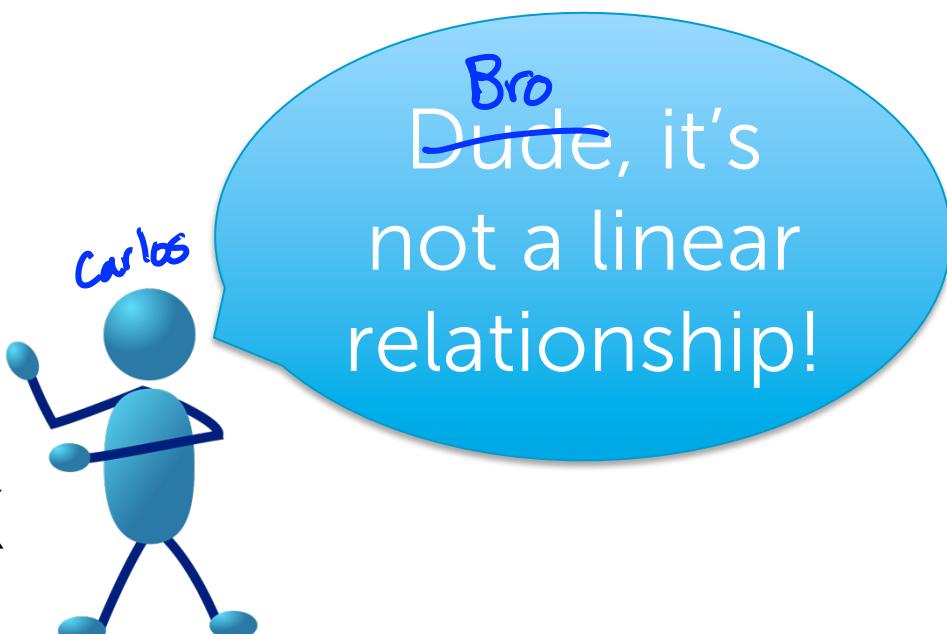
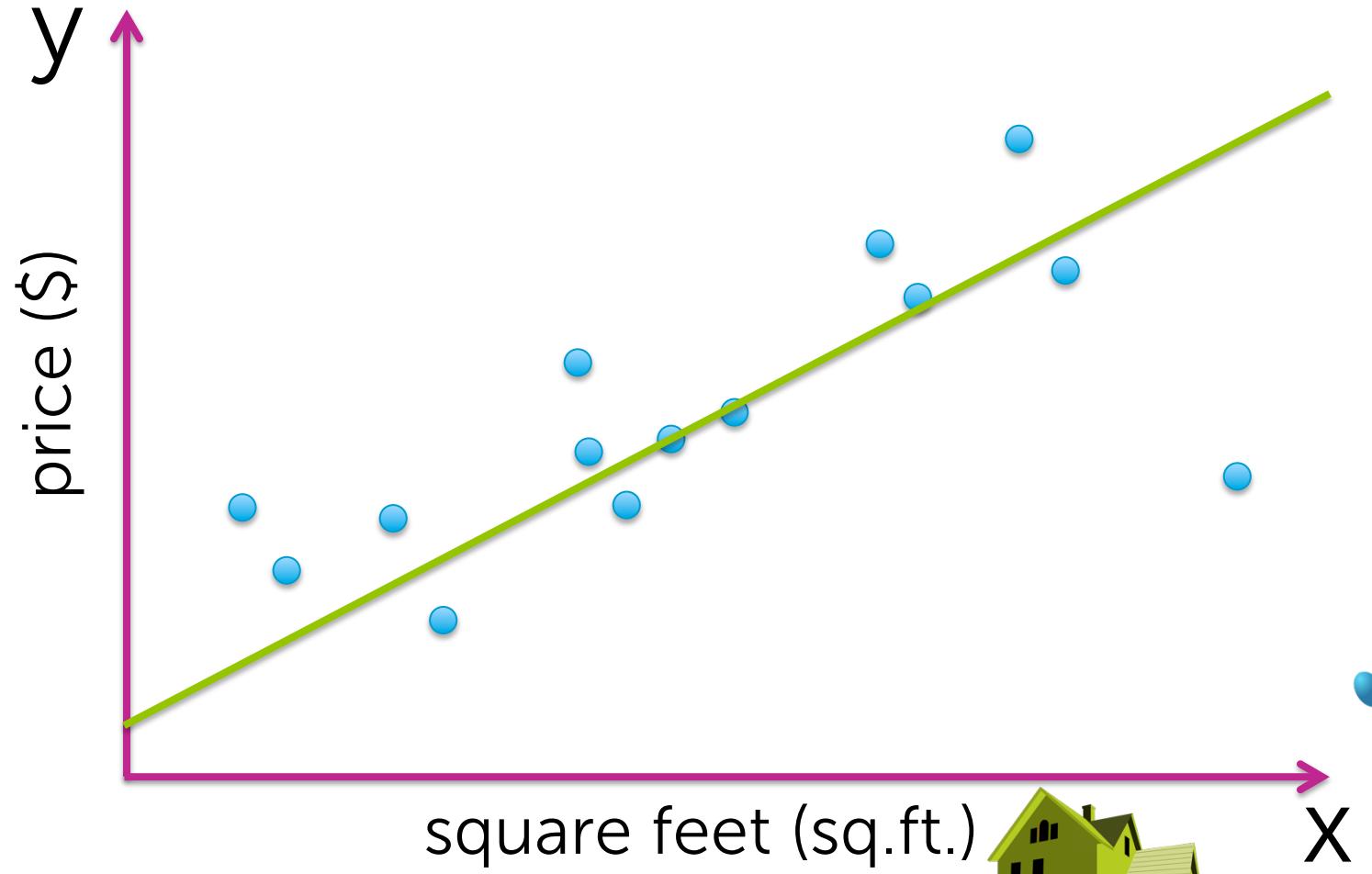
Adding higher order effects

Fit data with a line or ... ?

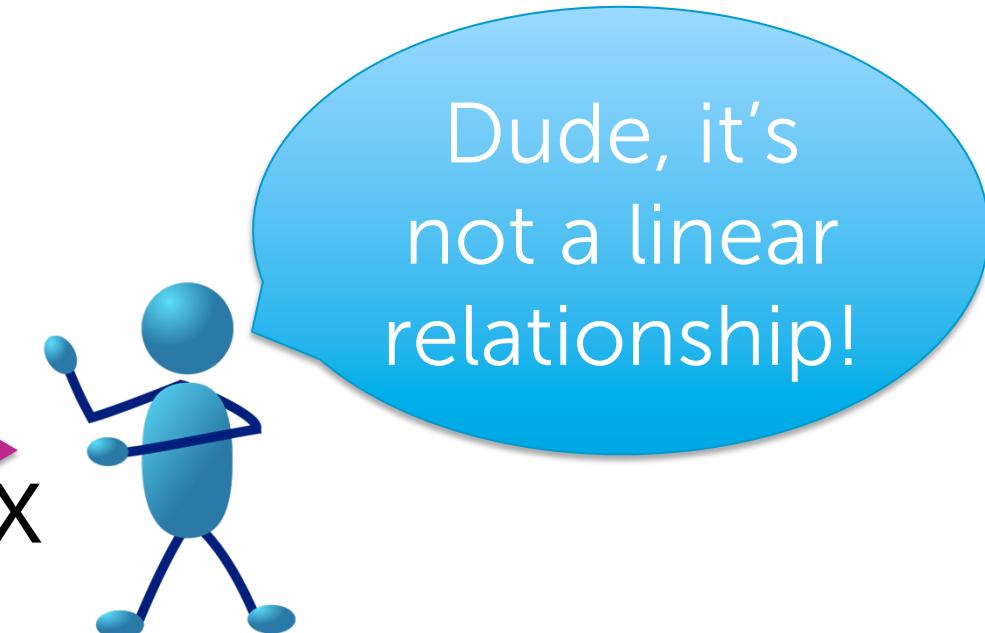
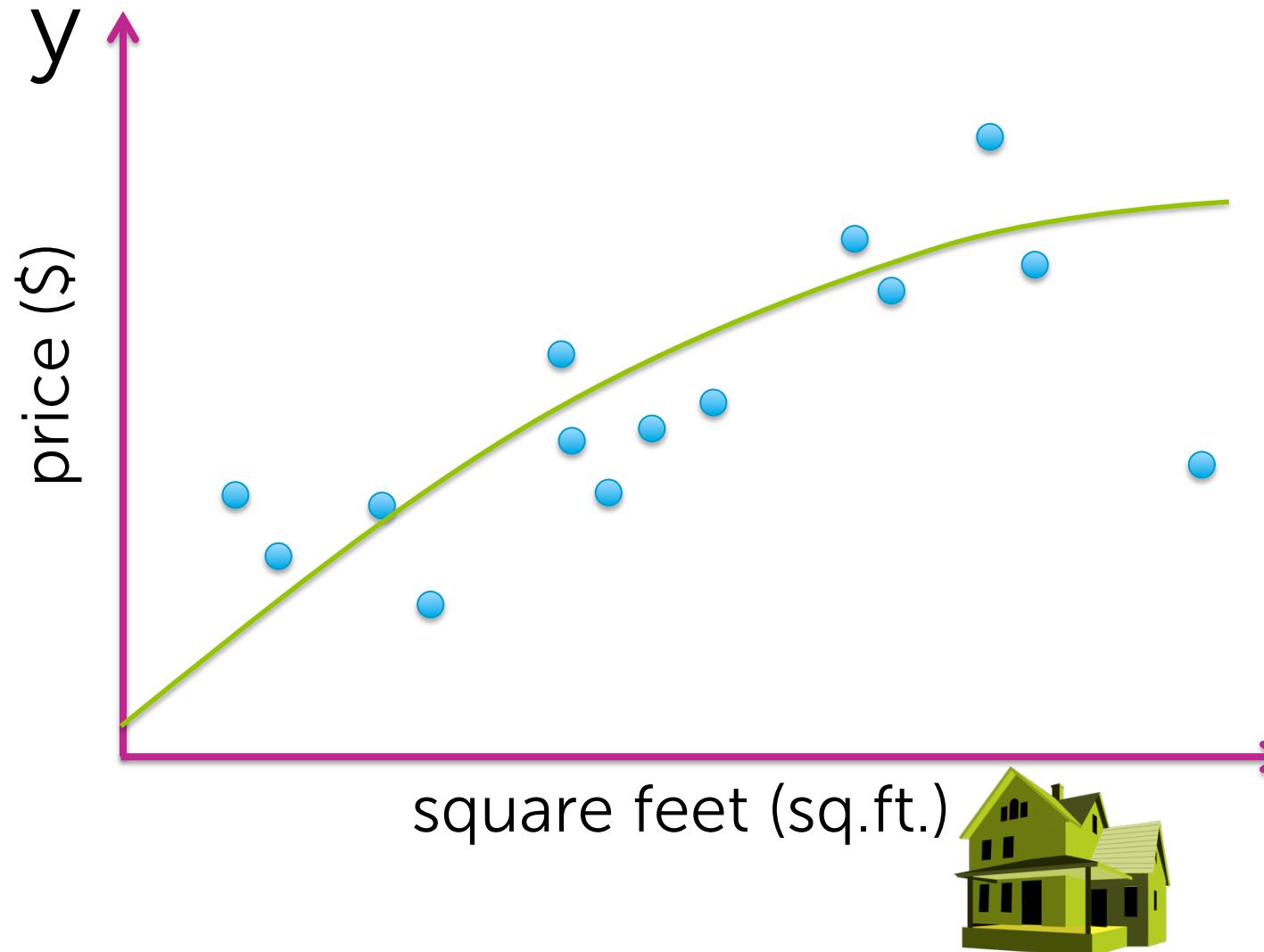


You show
your friend
your analysis

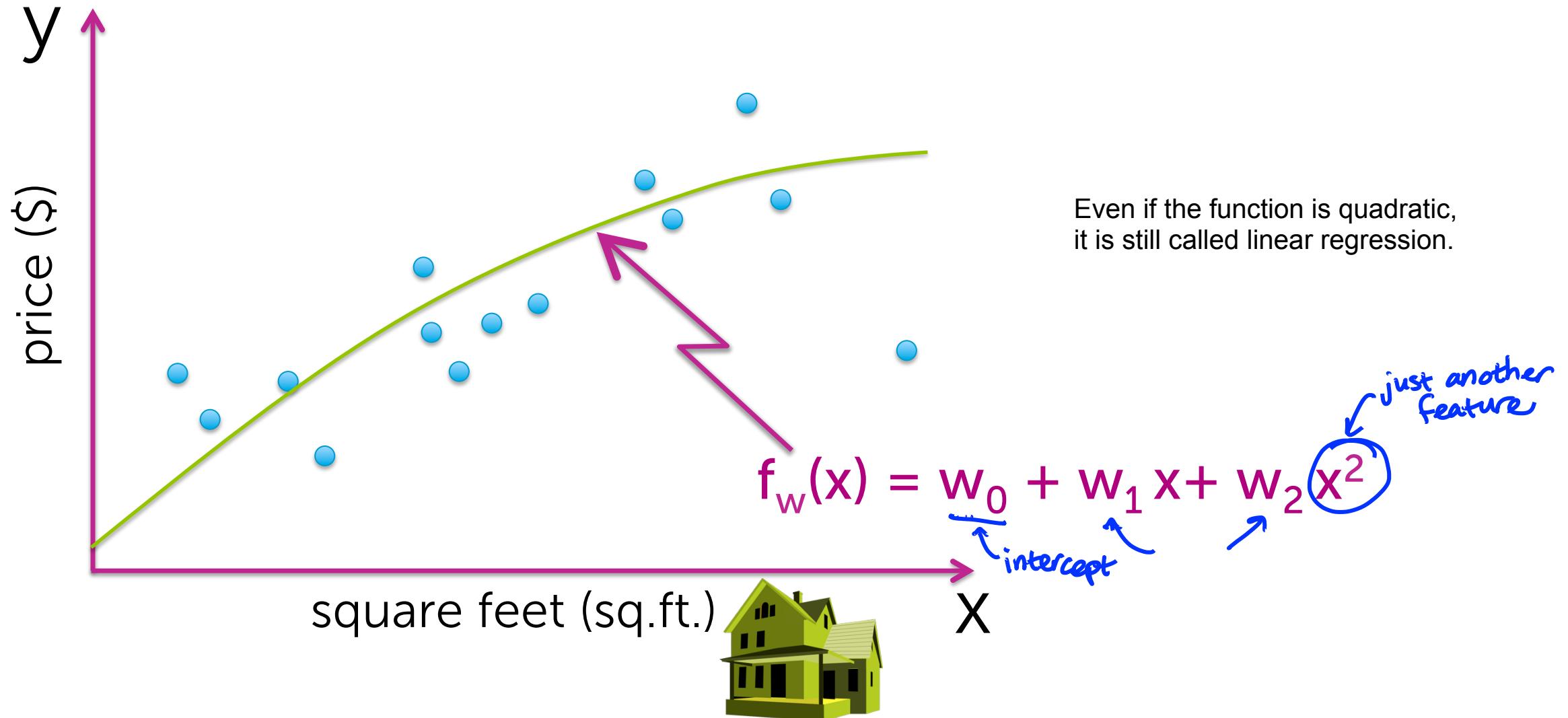
Fit data with a line or ... ?



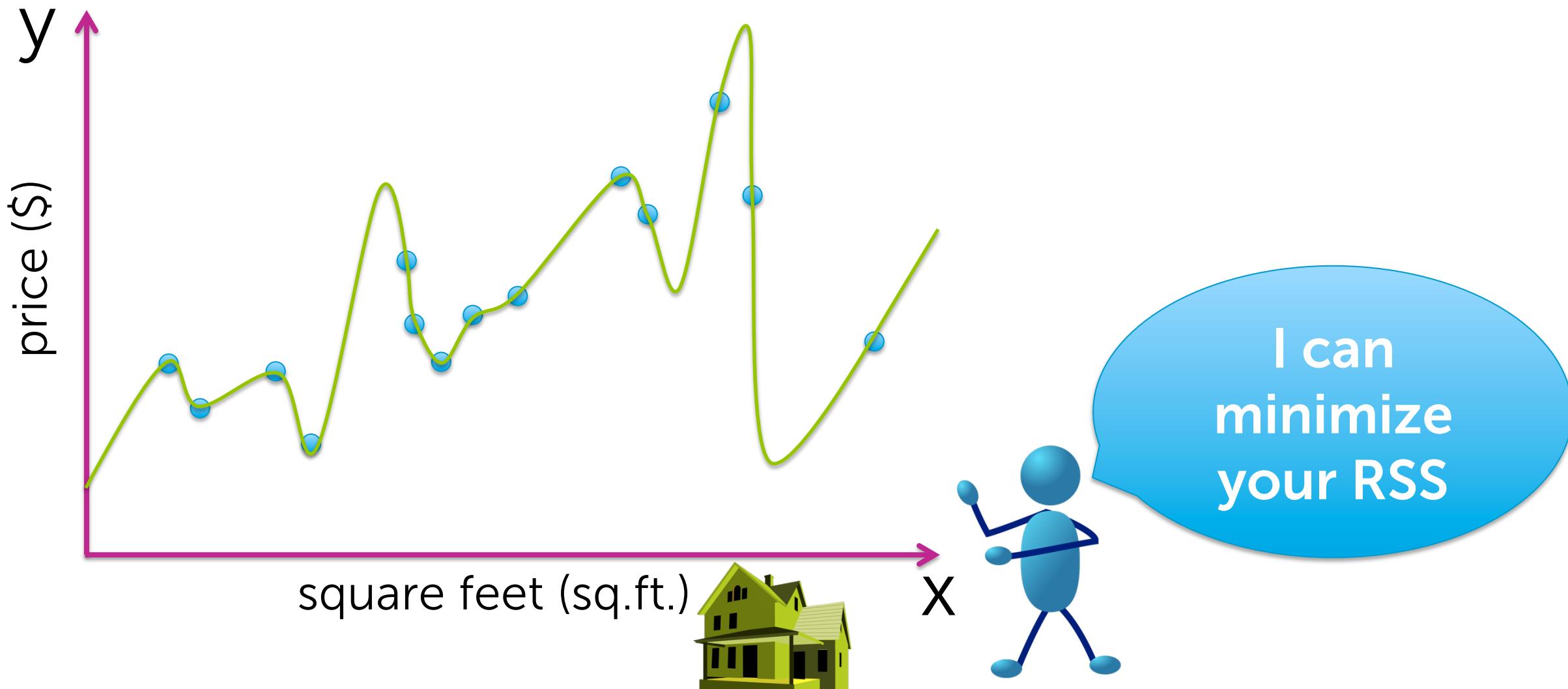
What about a quadratic function?



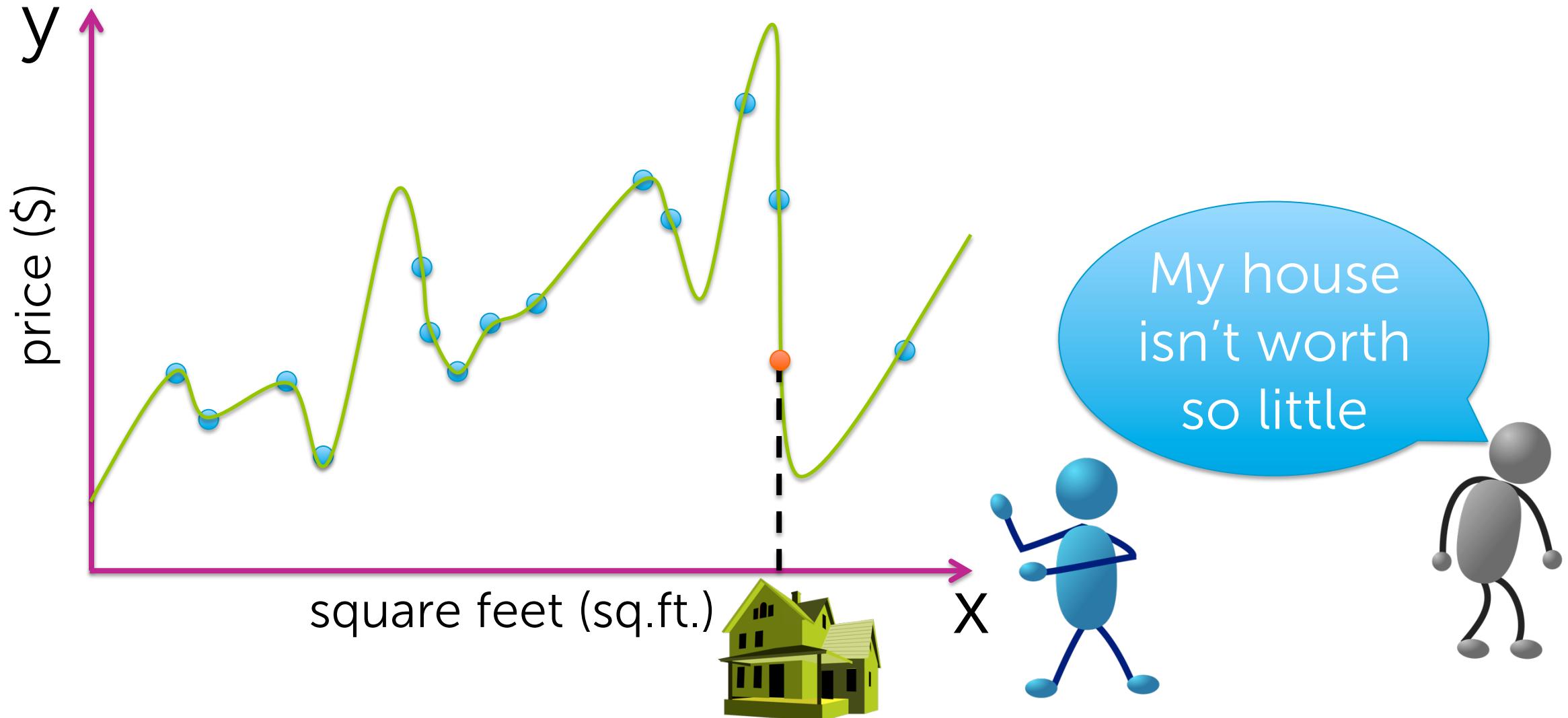
What about a quadratic function?



Even higher order polynomial

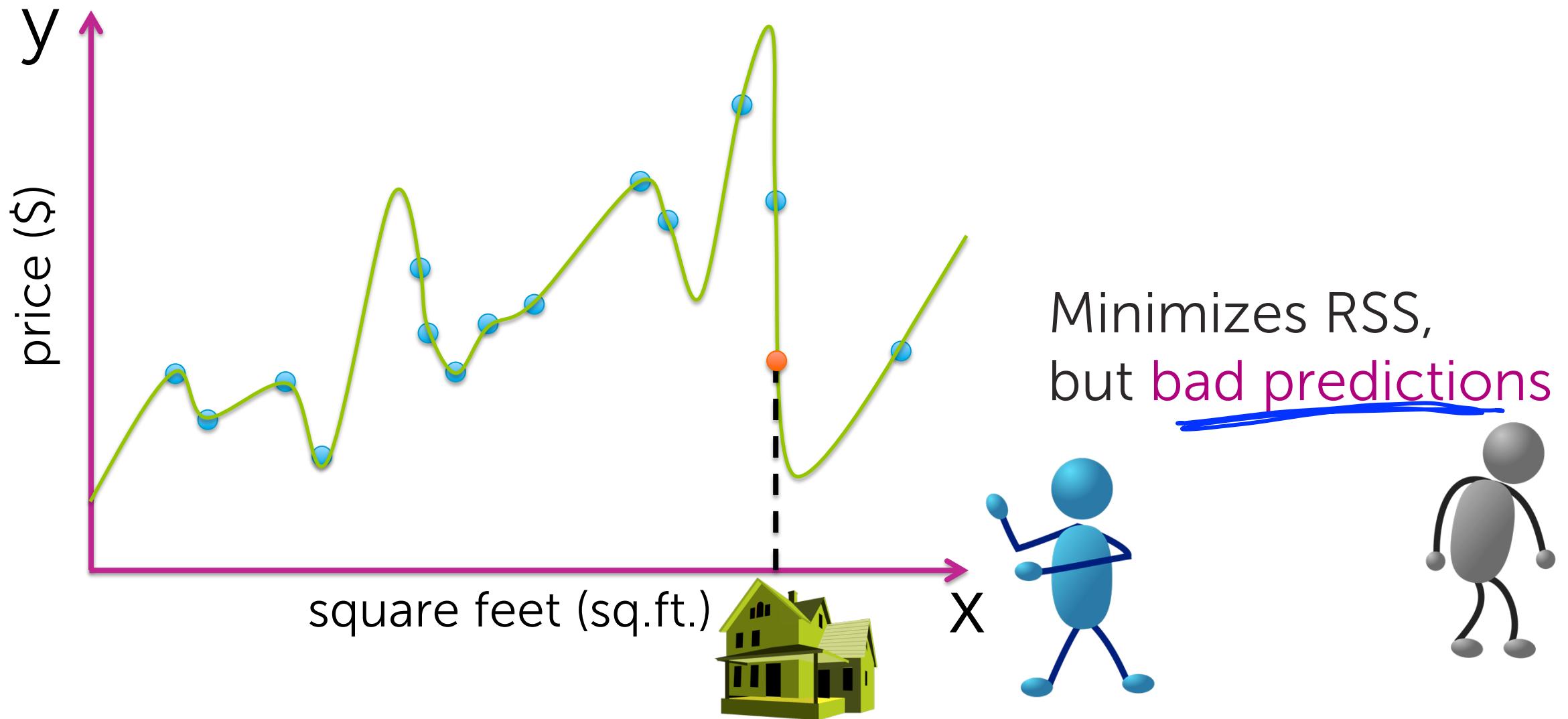


Do you believe this fit?

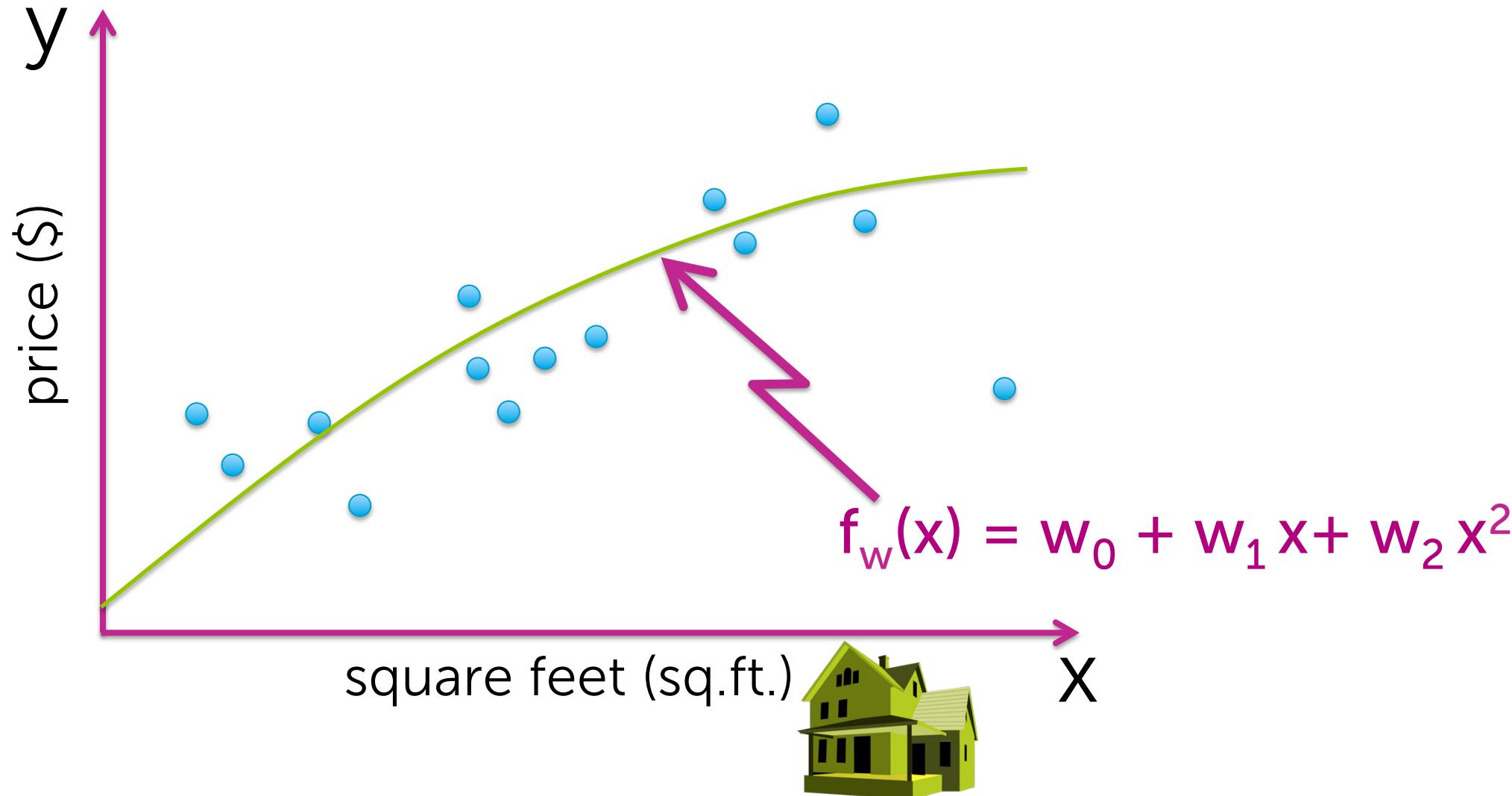


Evaluating overfitting via training/test split

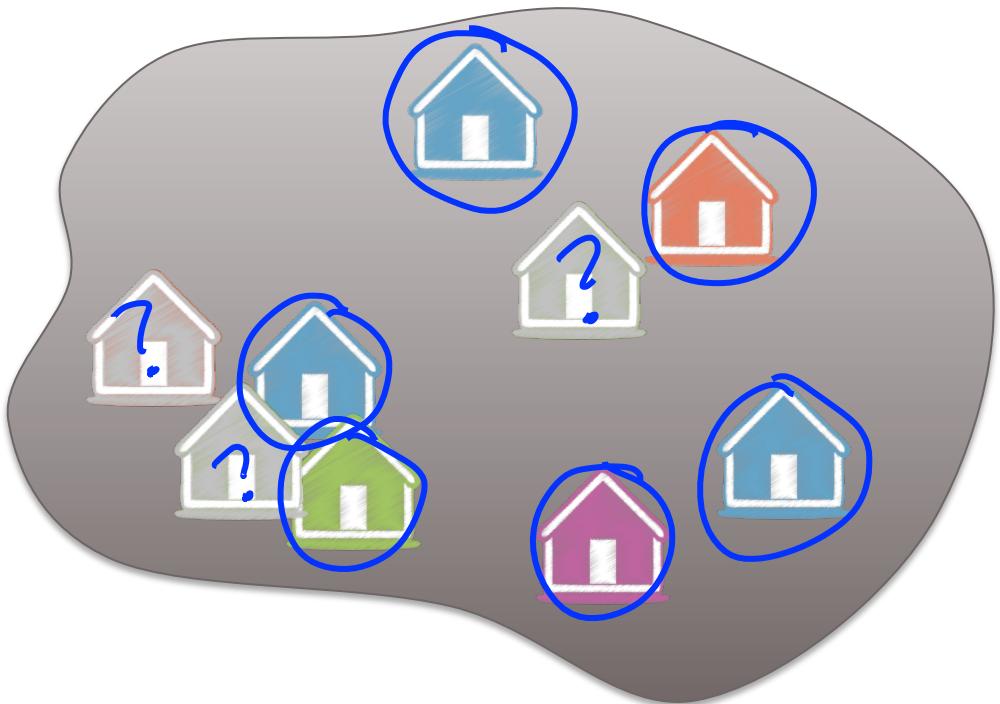
Do you believe this fit?



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

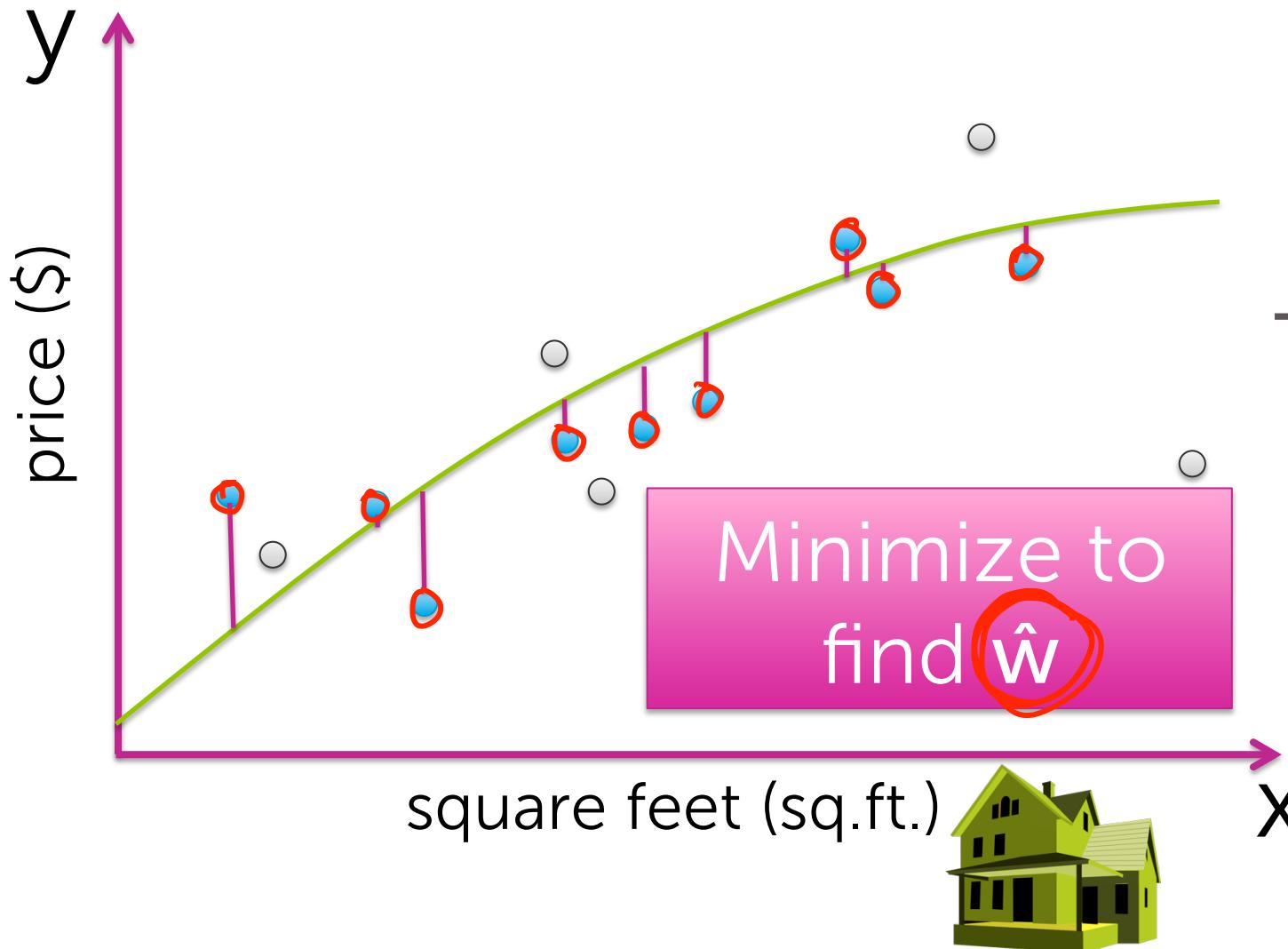


Terminology:

- training set
- test set

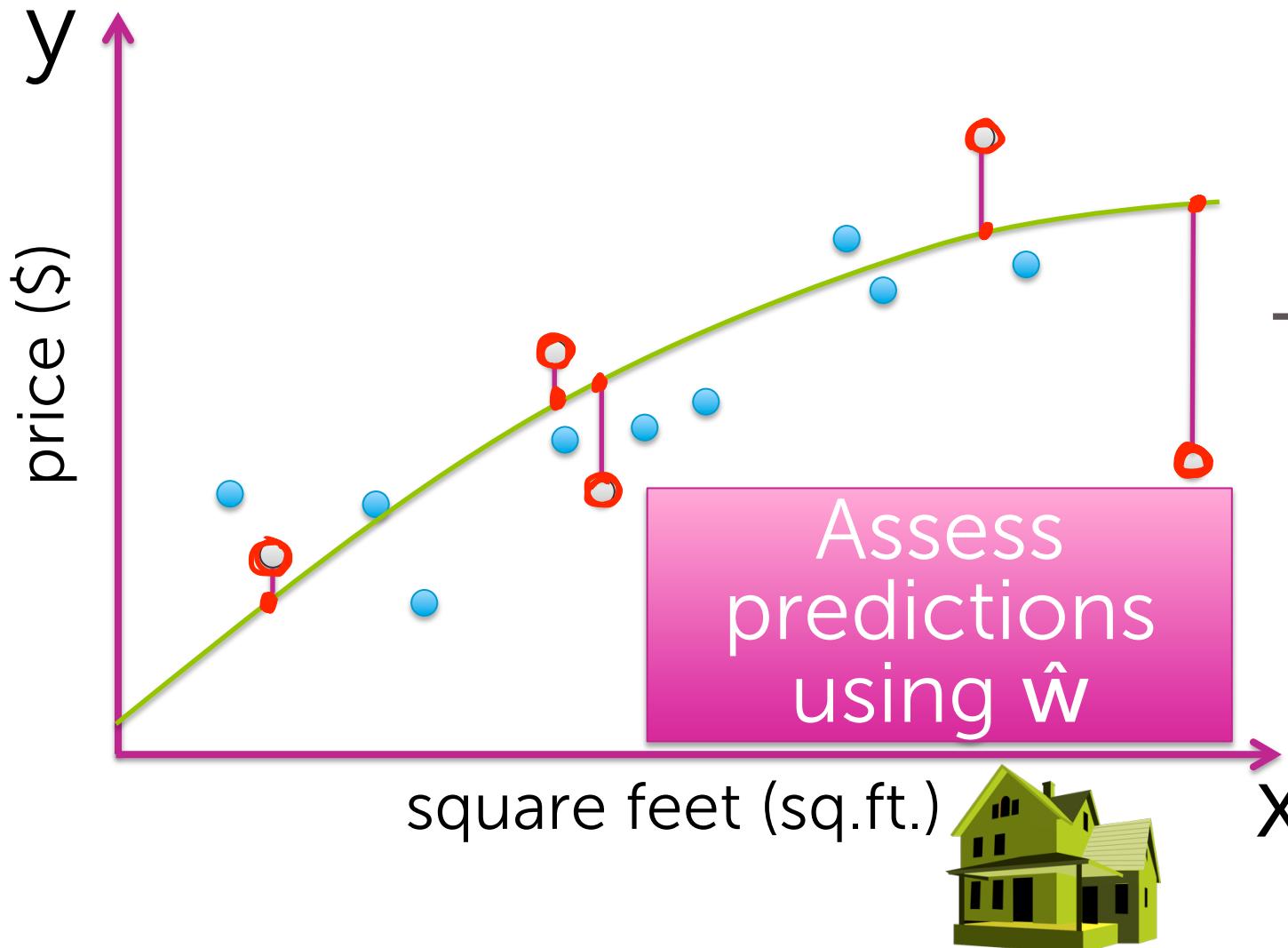


Training error



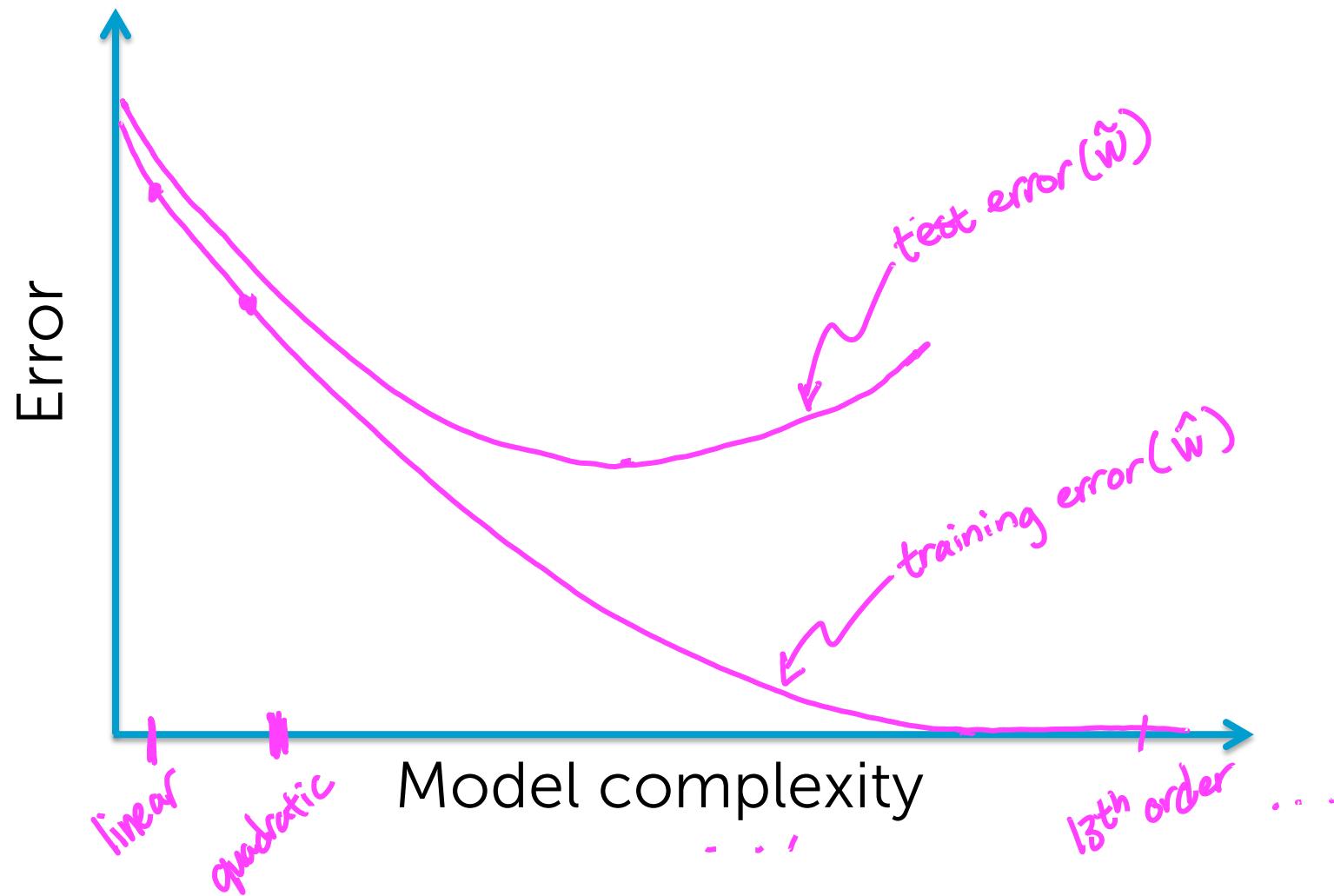
Training error (w) =
$$(\$_{\text{train } 1} - f_w(\text{sq.ft.}_{\text{train } 1}))^2$$
$$+ (\$_{\text{train } 2} - f_w(\text{sq.ft.}_{\text{train } 2}))^2$$
$$+ (\$_{\text{train } 3} - f_w(\text{sq.ft.}_{\text{train } 3}))^2$$
$$+ \dots$$
[include all training houses]

Test error



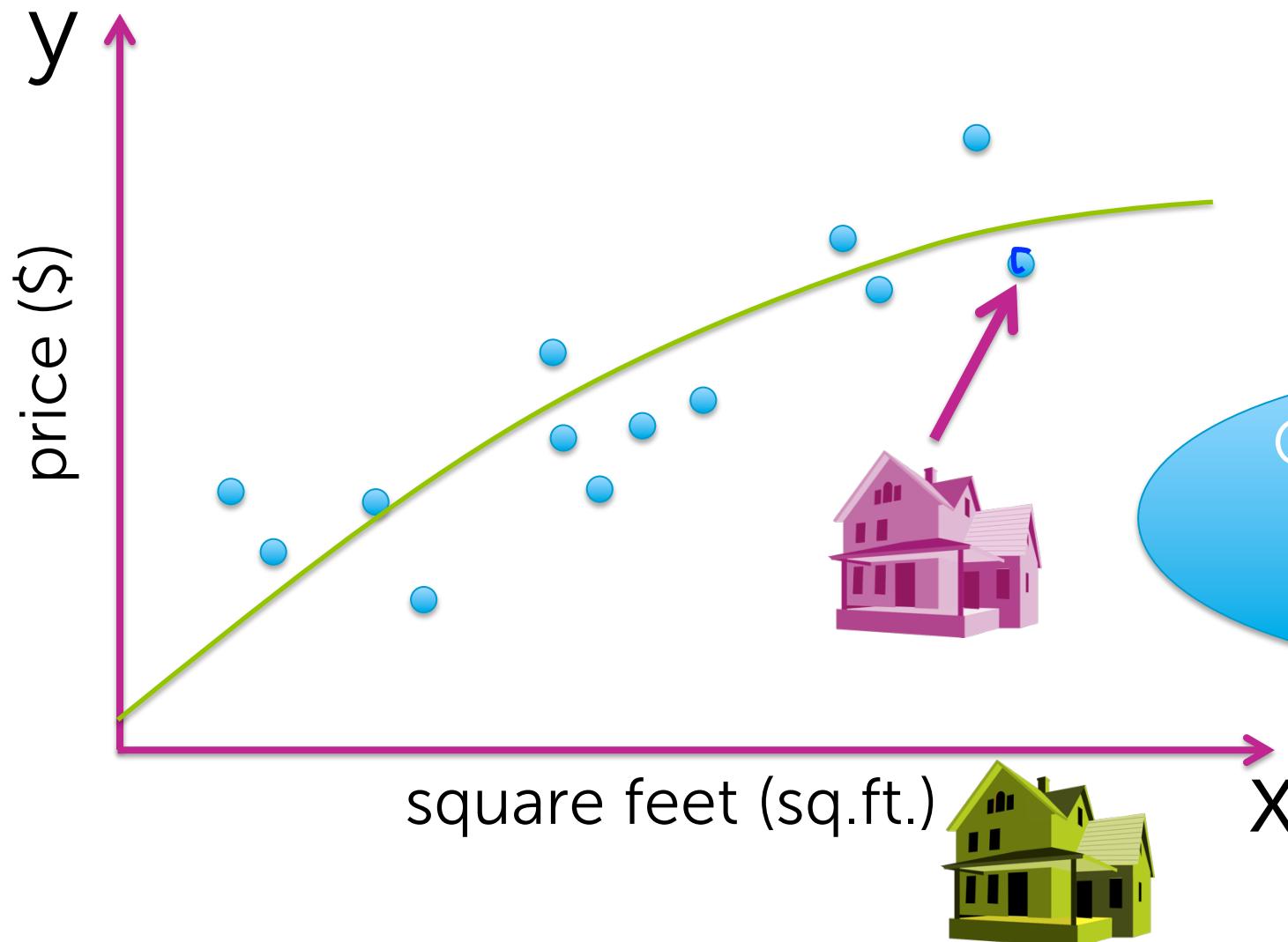
Test error $\hat{w} =$
 $(\$_{\text{test } 1} - f_{\hat{w}}(\text{sq.ft.}_{\text{test } 1}))^2$
 $+ (\$_{\text{test } 2} - f_{\hat{w}}(\text{sq.ft.}_{\text{test } 2}))^2$
 $+ (\$_{\text{test } 3} - f_{\hat{w}}(\text{sq.ft.}_{\text{test } 3}))^2$
+ ... [include all
test houses]

Training/Test Curves

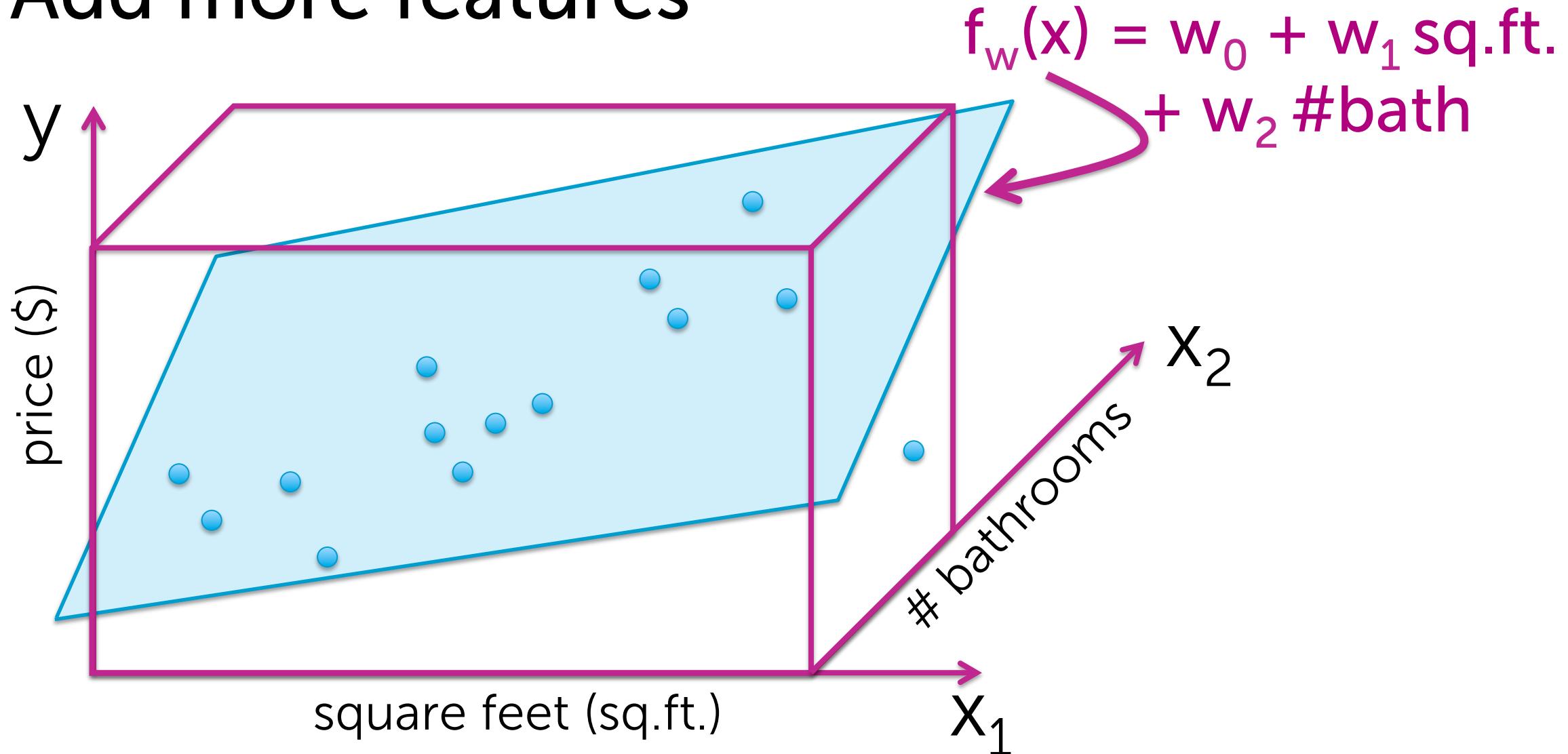


Adding other features

Predictions just based on house size



Add more features

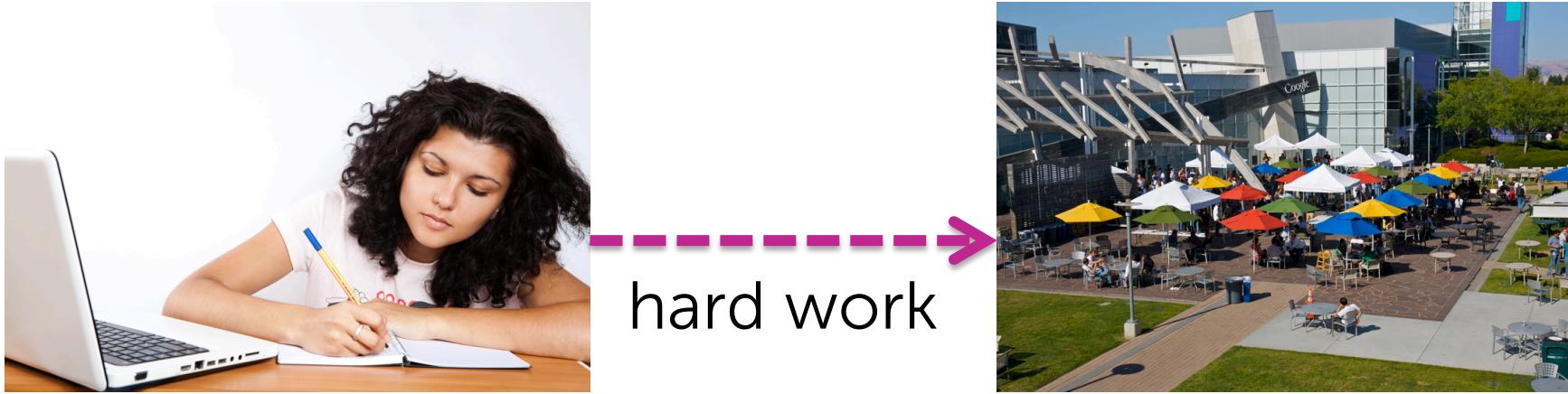


How many features to use?

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

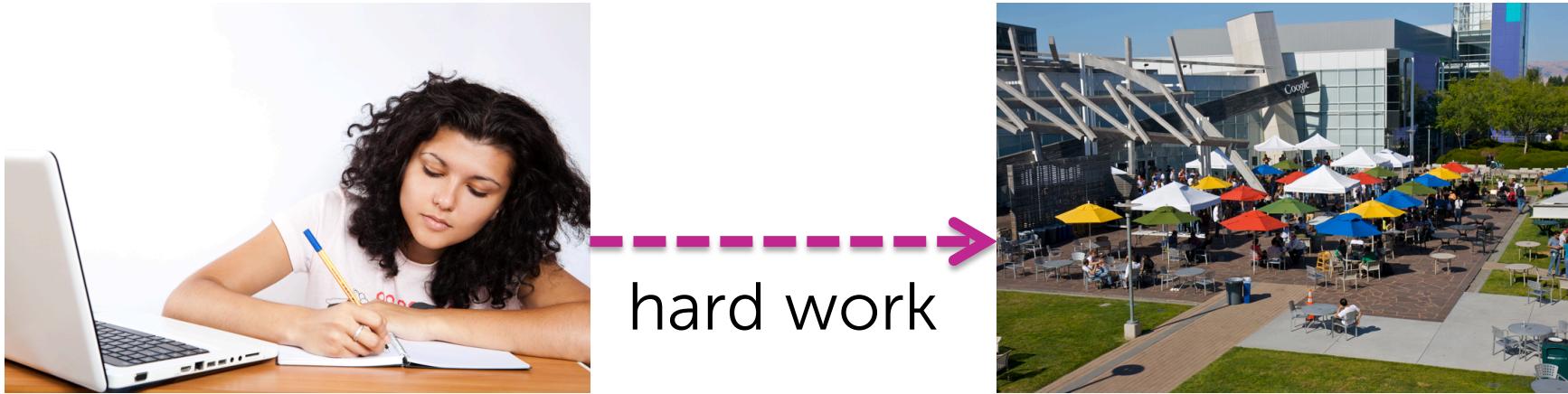
Other regression examples

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

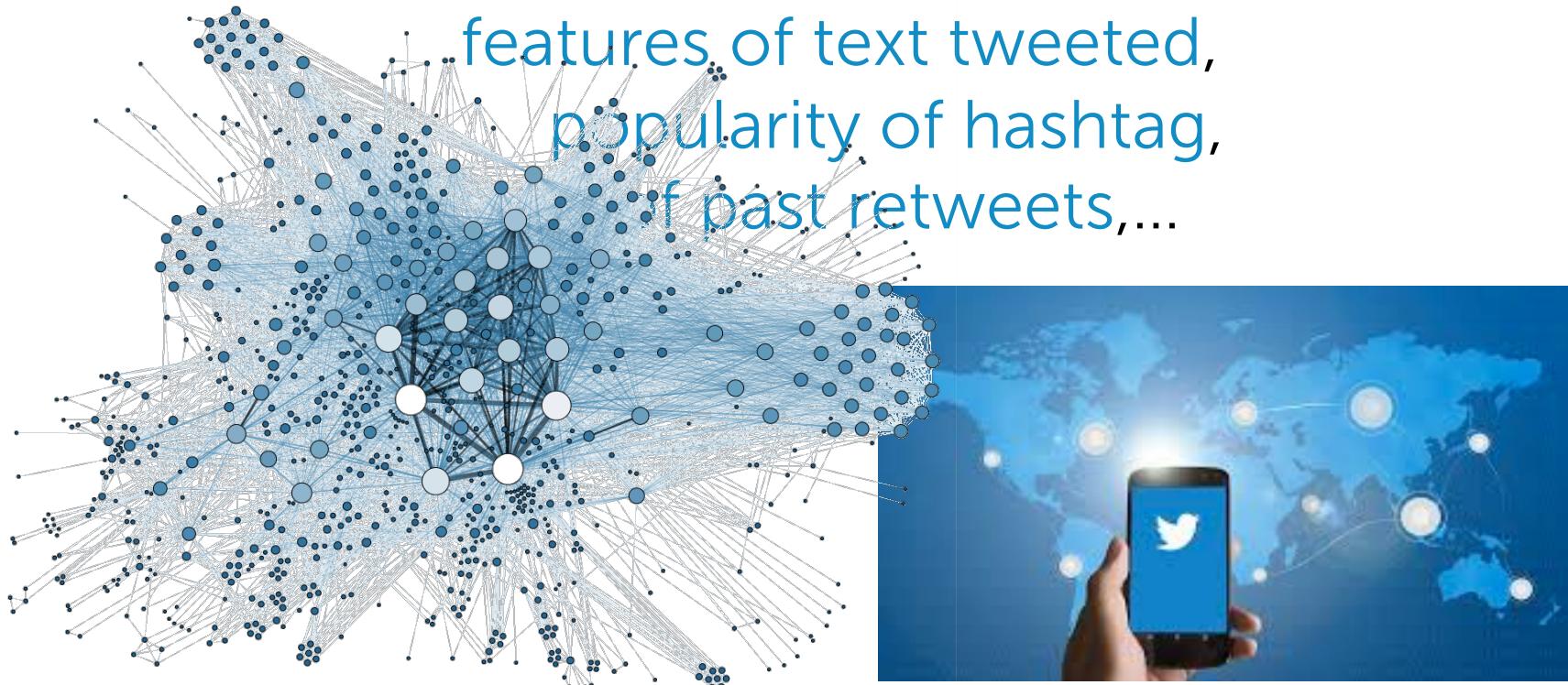
Stock prediction

- 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