Contents

1 Data

1.1 Generate

Generate data

```
(defparameter *bigdata* nil)

(with-open-file (stream (merge-pathnames "bigdata-typical.csv" *img-path*) :direction
   :if-exists :supersede)
  (let (bigdata)
    (loop for h from 3 to 4 by 0.5 do
      (loop for n from 1 to 16 do
(loop for bw from 3 to 6 by 0.5 do
  (loop for bx from 2 to 5 do
    (loop for by from bx to  5
  for exact = (simple-building-ftp* :number-of-storey n
    :height h
    :bays-x bx
    :bays-y by
    :bay-width bw
    :typical t)
  do
     (cl-csv:write-csv-row (list n h bw bx by exact)
   :stream stream)
     (push (list (list n h bw bx by) exact) bigdata))))))
    (setf *bigdata* bigdata)))
```

1.2 Read

```
     (let (bigdata)
       (cl-csv:read-csv (merge-pathnames "bigdata-typical.csv" *img-path*)
:data-map-fn #'(lambda (data &key csv-reader)
 (declare (ignore csv-reader))
 (let (( *read-default-float-format* 'double-float))
   (read-from-string data)))
:row-fn #'(lambda (row)
    (push (list (butlast row) (first (last row)))
  bigdata)))
       (setf *bigdata* (reverse bigdata)))
```

```
nil
```

```
NIL
```

2 Simple Fit

Simpler: T = a(Nh)^{b} is the best fit among the following 3.

2.1 T = a*N^{b}*h^{c}

```
(max-fit-%diff (lambda (x a b c)
 (destructuring-bind (n h bw bx by) x
   (* a
      (expt n b)
      (expt h c))))
       '(1 1 1)
       :save '/simple-fit)
```

max %diff	R^2	rmse	Params	Covariance
26.502044	0.960266	0.049727	(0.025120 0.759599 1.142994)	(0.000094 0.005615 0.069474)

2.2 Simpler: $\mathbf{T = a(Nh)^b}$

```
(max-fit-%diff (lambda (x a b)
   (destructuring-bind (n h bw bx by) x
     (* a
(expt (* n h) b)
)))
 ’(0.04 0.78)
 :save ’/simpler-fit)
```

max %diff	R^2	rmse	Params	Covariance
29.159699	0.950908	0.055265	(0.036801 0.788085)	(0.000101 0.005255)

The difference in R^2 of simple vs simpler formula is not much. And they explain almost 95% of the variation.

Tweaked coefficients

```
(max-fit-%diff (lambda (x a)
   (destructuring-bind (n h bw bx by) x
     (* 0.04
(expt (* n h) 0.78)
)))
 ’(1)
 :save ’/simpler-fit-tweaked)
```

```
(scatter-plot /simpler-fit-tweaked "tdsimpler-fit-tweaked.png")
```

2.3 Simplest: $\mathbf{T = a(N)^b}$

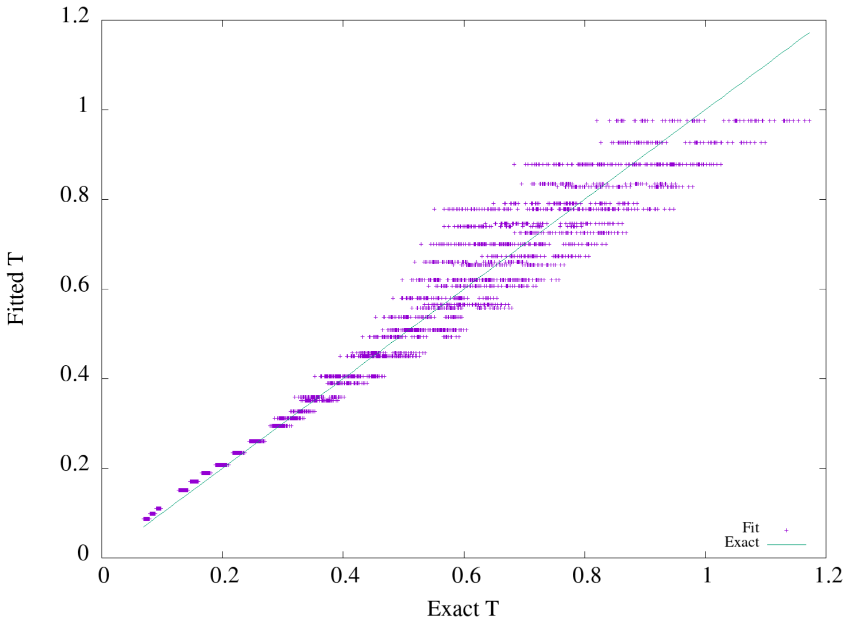
```
(max-fit-%diff (lambda (x a b)
 (destructuring-bind (n h bw bx by) x
   (* a
      (expt (* n) b)
      )))
       ’(1 1)
       :save ’/simplest-fit)
```

max %diff	R^2	rmse	Params	Covariance
36.321352	0.868721	0.090374	(0.106304 0.755588)	(0.000391 0.005680)

3 Plot

Scatter Plot of Simpler: $T = a(Nh)^b$

```
(scatter-plot /simpler-fit "tdsimpler-fit.png")
```



However with Nh only, the variation at higher T is very substantial. Hence other parameters must also be playing a great role in T.

4 Sensitivity Analysis

Is it bw or bx,by that play greater role.

Sensitivity of bw is max for h=4,bx=2,by=2. and descreases with decreasing n.

```
(sensitivity :bw (filter-data :n 16 :h 4 :bx 2 :by 2))
```

```
0\.493205189469148d0
```

Sensitivity with bx doesn't change much with bw.

```
(sensitivity :bx (filter-data :bw 6 :n 16 :h 4))
```

```
0\.04465106780108326d0
```

Hence timeperiod is more sensitive to bay width than with bay counts

4.1 with respect to N, h

```
(sensitivity :n (filter-data :h 4 :bw 3 :bx 5 :by 5))
```

```
0\.9152304123955828d0
```

```
(sensitivity :h (filter-data :n 16 :bw 3 :bx 2 :by 2))
```

```
1\.1670910918086783d0
```

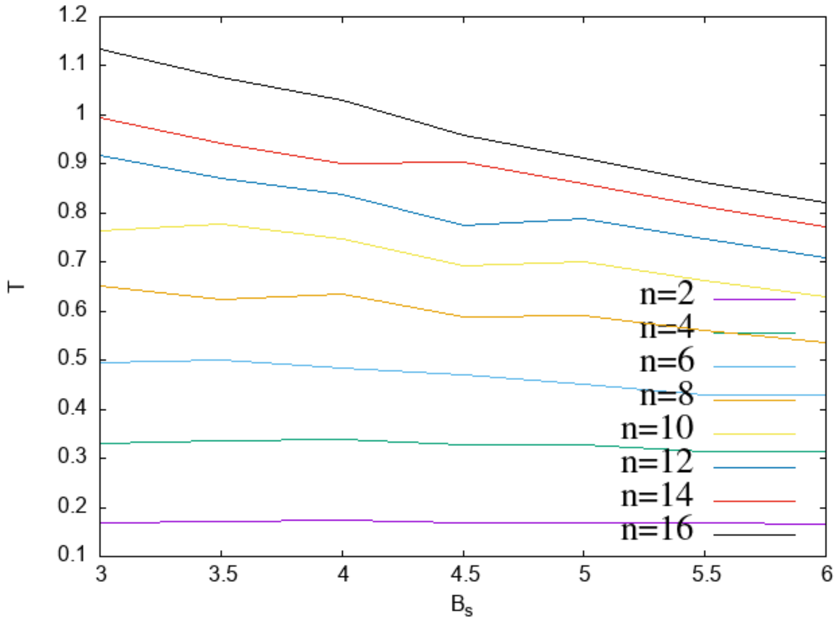
4.2 Max Variations

```
(table 4
  (row "N" "H" "Bs" "Bx" "By" "N and H" "Bx and By")
  (let ((results (loop for p in '(:n :h :bw :bx :by :nh :bxby)
       collect (multiple-value-list (max-effect p)))))
    (apply #'row (mapcar #'first results))
    (apply #'row (mapcar #'second results))))
```

5 Bay width

To incorporate bay width in the relation for fundamental time period. Lets see the variation of T with bw.

```
(with-plot "dbw.png"
  (setup :xlabel "B_s" :ylabel "T")
  (loop for n from 2 to 16 by 2 do
    (ezplot (mapcar (lambda (d)
      (destructuring-bind (x tp) d
(list (third x) tp)))
    (filter-data :n n :bx 2 :by 2 :h 4))
    :title (format nil "n=~d" n))))
```



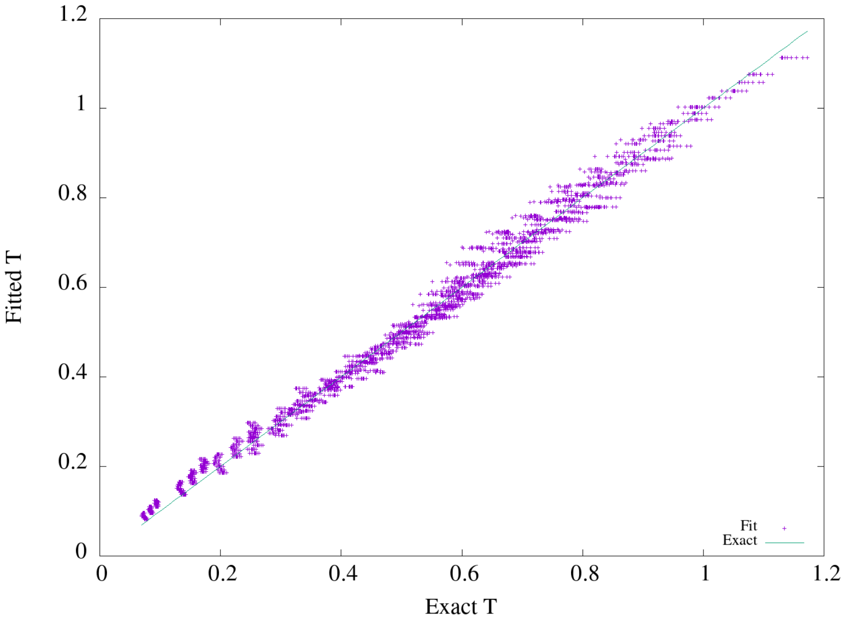
This shows that the time period decreases with bay width. and the rate of decrease/slope increases for higher N.

5.1 Simple Bw a(Nh)^b - c(N*bw)

```
(max-fit-%diff (lambda (x a b c)
 (destructuring-bind (n h bw bx by) x
   (- (* a
 (expt (* n h) b))
      (* c n bw)
 )))
       '(1 1 1)
       :save '/simpler-bw-fit)
```

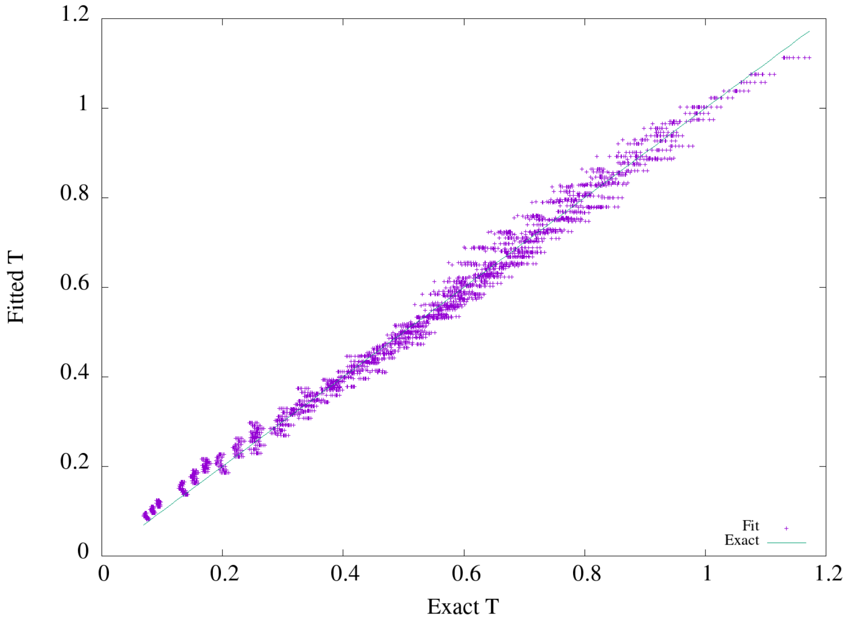
max %diff	R^2	rmse	Params	Covariance
27.669310	0.990159	0.024748	(0.044526 0.817145 0.004580)	(0.000093 0.003071 0.000003)

```
(scatter-plot /simpler-bw-fit "tdsimpler-bw-fit.png"
      (filter-data ))
```



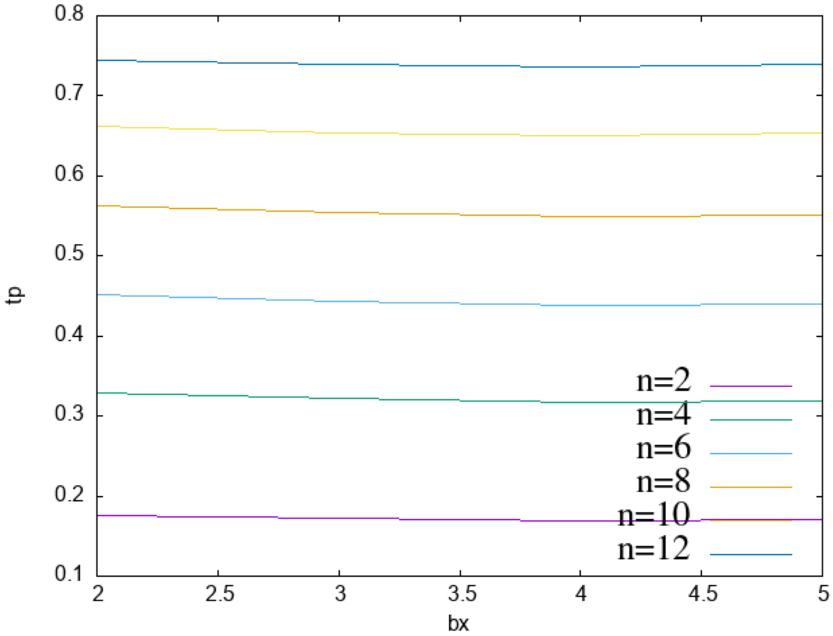
```
(max-fit-%diff (lambda (x a )
   (destructuring-bind (n h bw bx by) x
     (- (* 0.045
   (expt (* n h) 0.82))
(* 0.005 n bw)
   )))
 '(1)
 :save '/simpler-bw-fit-tweaked)

(scatter-plot /simpler-bw-fit "tdsimpler-bw-fit-tweaked.png")
```



6 Bx,By

```
(with-plot "tdbx.png"
  (setup :xlabel "bx" :ylabel "tp")
  (loop for n from 2 to 12 by 2 do
    (ezplot (mapcar (lambda (d)
      (destructuring-bind (x tp) d
(list (fourth x) tp)))
    (filter-data :n n :bw 6 :by 5 :h 4))
    :title (format nil "n=~d" n))))
```



This shows that T is almost constant with bx. Which was also indicated by smaller sensitivity of tp with bx.