Bifurcation Diagrams

May 10, 2020

[2]:
```
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
```

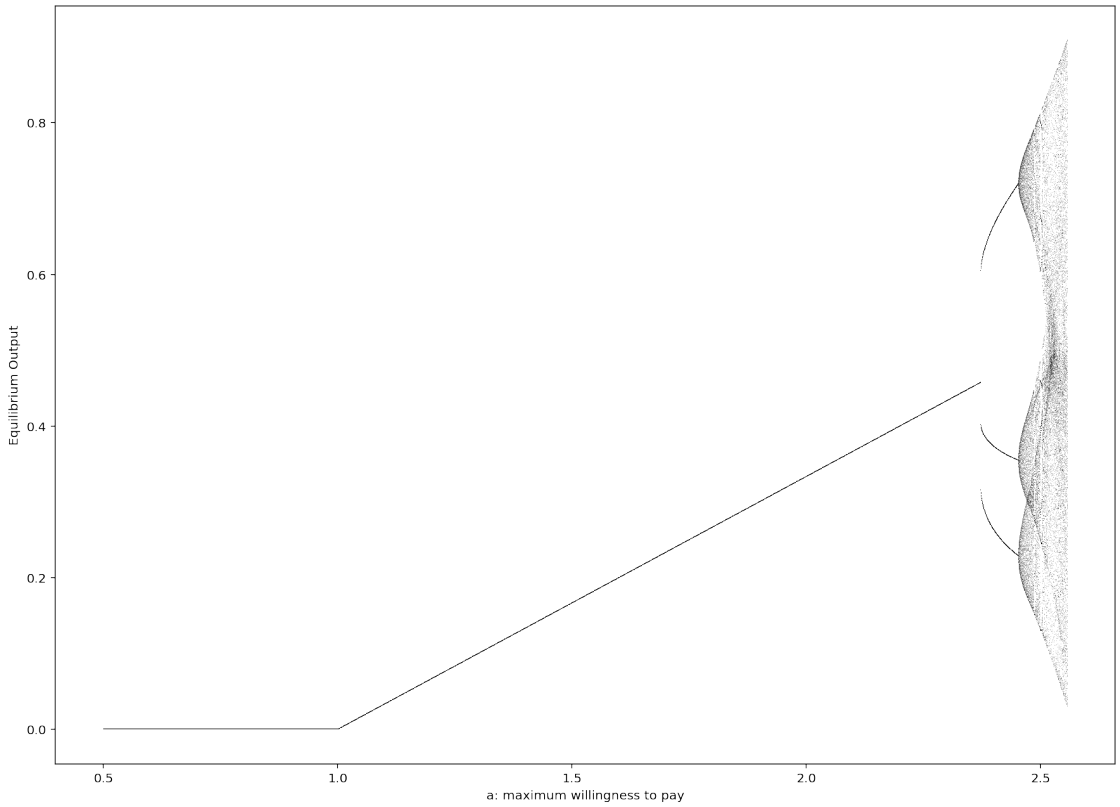
[3]:
```
n = 10000
a = np.linspace(.5, 4.0, n)
iterations = 10000
last = 100
x = 1e-5 * np.ones(n)
y = 1e-5 * np.ones(n)

def myop_map(x,y, alpha1,alpha2, a,b,c, n):

    return x + alpha1*x*(a-c-2*b*x-b*y),  y + alpha2*y*(a-c-2*b*y-b*x)
```

[4]:
```
plt.figure(figsize=(15, 11))
for i in range(iterations):
    x = myop_map(x,y, 2,2, a,1,1, n)[0]
    y = myop_map(x,y, 2,2, a,1,1, n)[1]

    if i >= (iterations - last):
        plt.plot(a, x, ',k', alpha=0.25)

plt.xlabel('a: maximum willingness to pay')
plt.ylabel('Equilibrium Output')
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel/__main__.py:10: RuntimeWarning:
overflow encountered in multiply
/usr/local/lib/python3.6/dist-packages/ipykernel/__main__.py:10: RuntimeWarning:
invalid value encountered in add
/usr/local/lib/python3.6/dist-packages/ipykernel/__main__.py:10: RuntimeWarning:
invalid value encountered in subtract
```

[4]:
```
Text(0, 0.5, 'Equilibrium Output')
```

[4]:



[5]:
```
plt.figure(figsize=(15, 11))
alpha1 = 2
alpha2 = 2

a = np.linspace(2.362, 2.7, n)
b = 1
c = 1

plt.figure(figsize=(11, 8))
for i in range(iterations):
    x = myop_map(x,y, alpha1,alpha2, a,b,c, n)[0]
    y = myop_map(x,y, alpha1,alpha2, a,b,c, n)[1]

    if i >= (iterations - last):
        plt.plot(a, x, ',k', alpha=0.25)

plt.xlabel('a: maximum willingness to pay')
plt.ylabel('Equilibrium Output')
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel/__main__.py:10: RuntimeWarning:
overflow encountered in multiply
/usr/local/lib/python3.6/dist-packages/ipykernel/__main__.py:10: RuntimeWarning:
```

```
invalid value encountered in subtract
/usr/local/lib/python3.6/dist-packages/ipykernel/__main__.py:10: RuntimeWarning:
invalid value encountered in add
```

[4]:
```
plt.figure(figsize=(15, 11))
alpha1 = 2
alpha2 = 2
n = 10000
a = 3
b = 1
c = np.linspace(0.1, 4, n)

plt.figure(figsize=(11, 8))
for i in range(iterations):
    x = myop_map(x,y, alpha1,alpha2, a,b,c, n)[0]
    y = myop_map(x,y, alpha1,alpha2, a,b,c, n)[1]

    if i >= (iterations - last):
        plt.plot(c, x, ',k', alpha=0.25)

plt.xlabel('c: cost of production per unit')
plt.ylabel('Equilibrium Output')
```

```
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/usr/local/lib/python3.6/dist-packages/ipykernel/__main__.py:10: RuntimeWarning:
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```
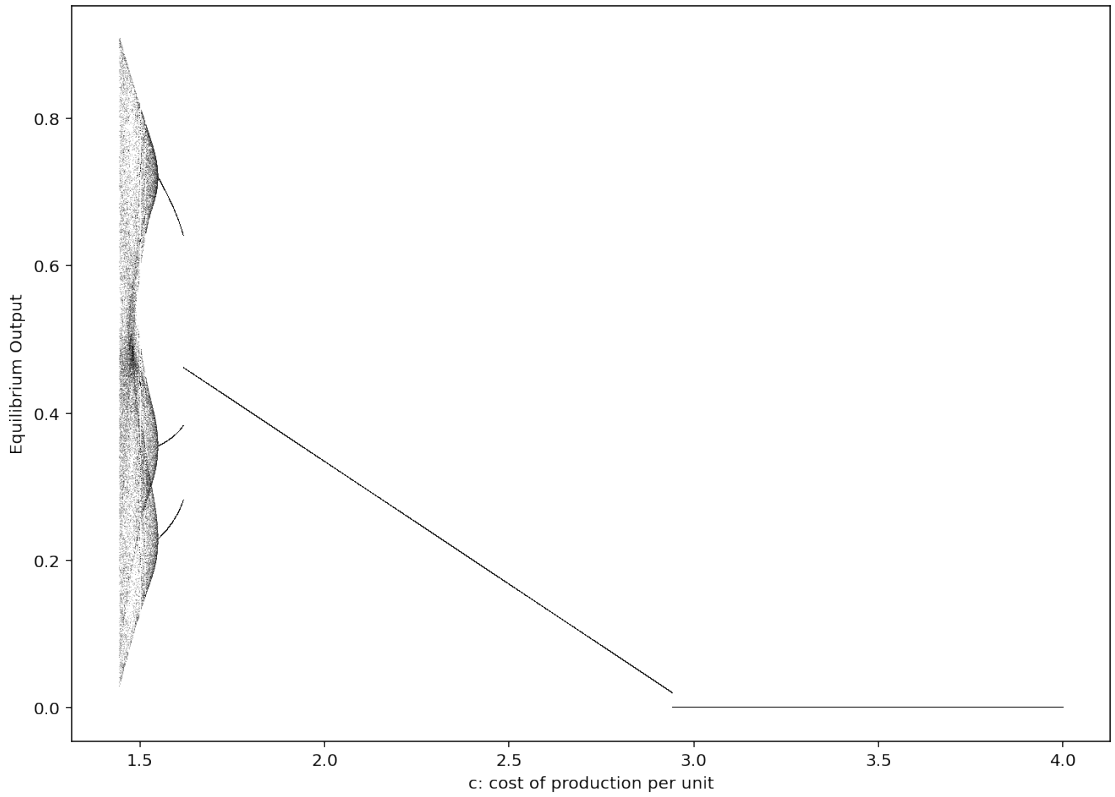

[4]:
```
Text(0, 0.5, 'Equilibrium Output')
```

[4]:
```
<Figure size 1080x792 with 0 Axes>
```

[4]:



[8]:
```
plt.figure(figsize=(15, 11))
alpha = np.linspace(.5, 4.0, n)
x = 1e-5 * np.ones(n)
y = 1e-5 * np.ones(n)

for i in range(iterations):
    x = myop_map(x,y, alpha,alpha, 2,1,1, n)[0]
    y = myop_map(x,y, alpha,alpha, 2,1,1, n)[1]

    if i >= (iterations - last):
        plt.plot(alpha, x, ',k', alpha=.25)

plt.xlabel('alpha: speed of adjustment')
plt.ylabel('Equilibrium Output')
```

```
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invalid value encountered in add
```
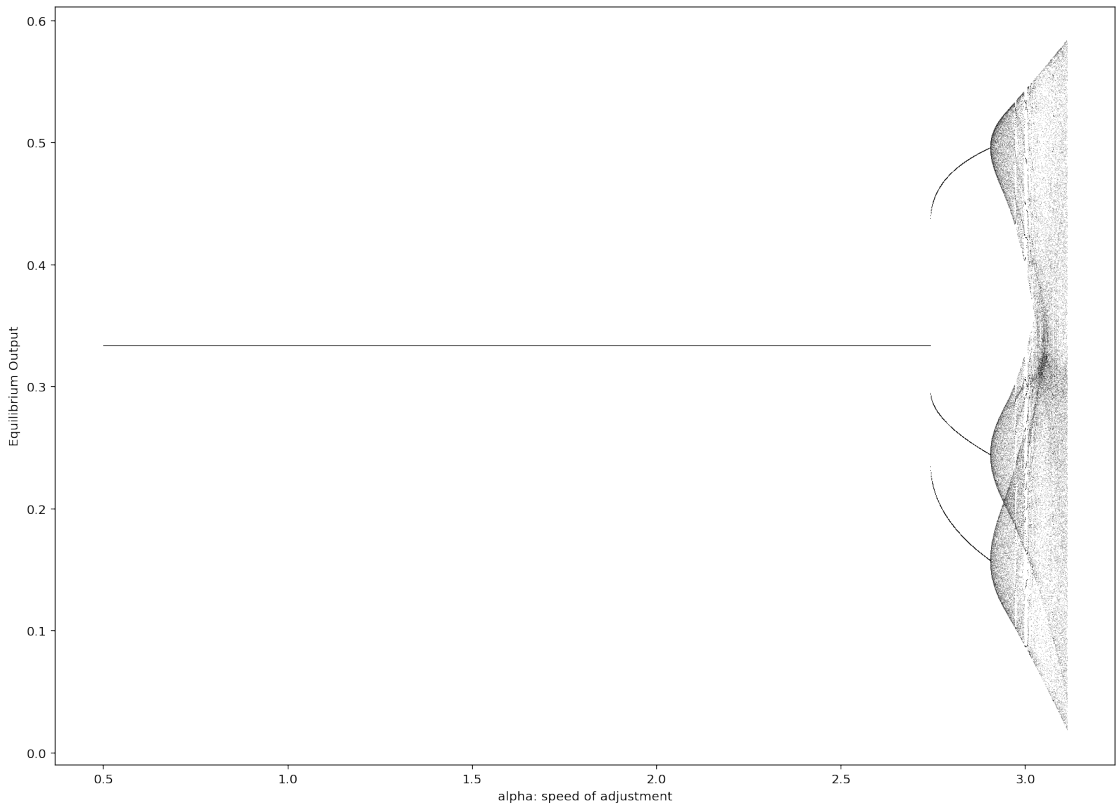

[8]: Text(0, 0.5, 'Equilibrium Output')

[8]:



[9]:
```
plt.figure(figsize=(15, 11))
alpha1 = 2
alpha2 = 0.25

a = np.linspace(0.5, 3, n)
b = 1
c1 = 0.5
c2 = 1.5

x = 1e-5 * np.ones(n)
y = 1e-5 * np.ones(n)

for i in range(iterations):
    x = myop_map(x,y, alpha1,alpha1, a,b,c1, n)[0]
    y = myop_map(x,y, alpha1,alpha1, a,b,c2, n)[1]

    if i >= (iterations - last):
        plt.plot(a, x, ',k', alpha=.25)
```

```
plt.xlabel('a: maximum willingness to pay')
plt.ylabel('Equilibrium Output')
```

```
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```
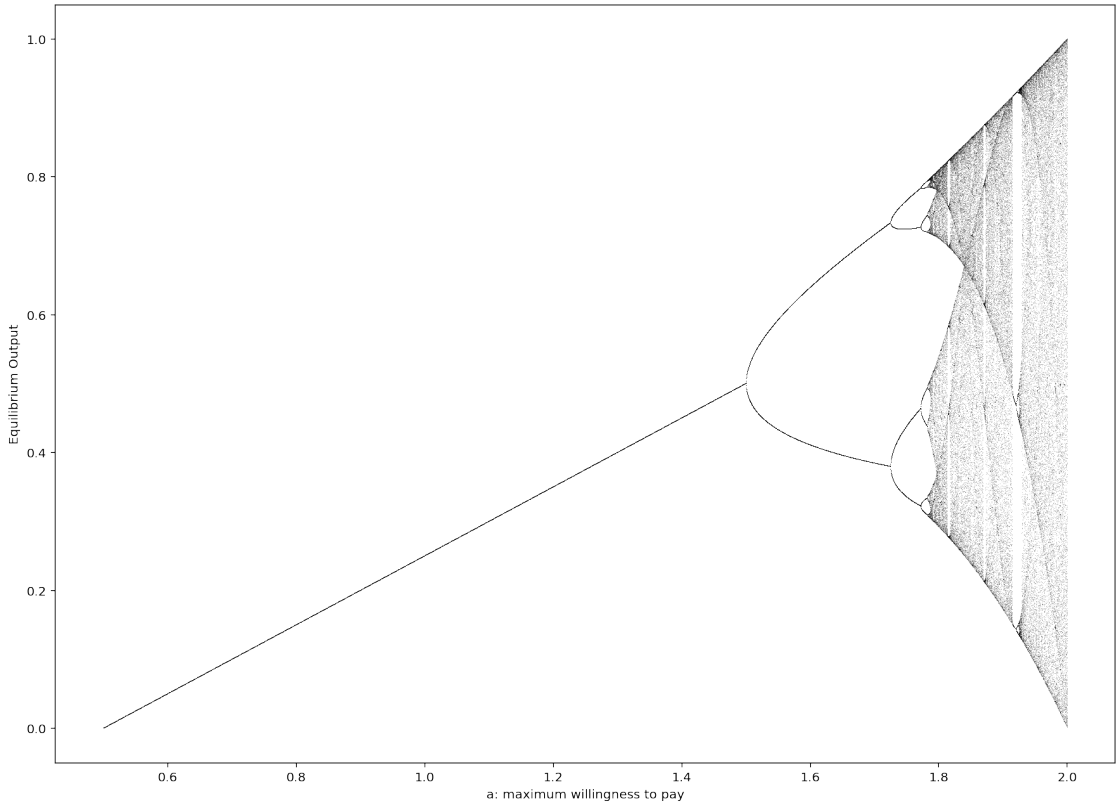

[9]:
```
Text(0, 0.5, 'Equilibrium Output')
```

[9]:



[0]:

[0]:

[0]: