A Benefit-Cost Analysis of the Multiplier Effect

by Erik Rose, MPA
PhD Student
Oregon State University
2017 Society for Benefit-Cost Analysis Conference
Merriam-Webster definition of *multiplier effect*:

the effect of a relatively minor factor in precipitating a great change; especially: the effect of a relatively small change in one economic factor (such as rate of saving or level of consumer credit) in inducing a disproportionate increase or decrease in another (such as gross national product)
Merriam-Webster definition of *multiplier effect*:

the effect of a relatively minor factor in precipitating a great change; especially: the effect of a relatively small change in one economic factor (such as rate of saving or level of consumer credit) in inducing a disproportionate increase or decrease in another (such as gross national product)

Proposed functional BCA definition of *multiplier effect*:
Merriam-Webster definition of *multiplier effect*:

the effect of a relatively minor factor in precipitating a great change; especially: the effect of a relatively small change in one economic factor (such as rate of saving or level of consumer credit) in inducing a disproportionate increase or decrease in another (such as gross national product)

Proposed functional BCA definition of *multiplier effect*:

The effect of present spending on future income.
Network Model of Currency Flow

$ Initial Spending - Money introduced into circulation in a time period t

N Network N - Consisting of members N = { 1, 2, 3 ... n }

C Consumers - Monetary transactions between individuals

O Out of Network Spending - Currency flow to non-members
Network Model of Currency Flow

For an individual $i$ in network $N = \{1, 2, 3 \ldots n\}$, circulation $c$ occurs when a unit of currency spent by an individual returns to the individual within a time period $p$

$$c_A = c_B = c_C = 0 \quad c_D = 1 \quad c_E = 2 \quad c_F = 3$$

The **responding rate** $\rho$ for node $i$ is circulation $c$ divided by the total amount spent.

$$\rho_A = \rho_B = \rho_C = 0/1 = 1 \quad \rho_D = 1/2 = 0.5 \quad \rho_E = 2/3 = 0.67 \quad \rho_F = 3/4 = 0.75$$
Network Model of Currency Flow

Respending over N:

\[
\rho_N = \frac{\sum_{i=1}^{n} c_i}{\text{Total Spending}}
\]
Network Model of Currency Flow

Responding over $N$:

$$\rho_N = \frac{\sum_{i=1}^{n} c_i}{\text{Total Spending}}$$

- Responding over $N$ is the average responding rate of nodes in the network
Network Model of Currency Flow

Total Spending

\[ \rho_N = \frac{\sum_{i=1}^{n} c_i}{\text{Total Spending}} \]

- Respending over N is the average respending rate of nodes in the network.
- Recirculating currency by definition occurs among nodes in the network.
Network Model of Currency Flow

Respending over N:

\[ \rho_N = \frac{\sum_{i=1}^{n} c_i}{\text{Total Spending}} \]

- Respending over N is the average respending rate of nodes in the network.
- Recirculating currency by definition occurs among nodes in the network.

<table>
<thead>
<tr>
<th>Total Value</th>
<th>Respending = 65%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.65</td>
</tr>
<tr>
<td>1.65</td>
<td>0.42</td>
</tr>
<tr>
<td>2.07</td>
<td>0.27</td>
</tr>
<tr>
<td>2.35</td>
<td>0.18</td>
</tr>
<tr>
<td>2.53</td>
<td>0.12</td>
</tr>
<tr>
<td>2.64</td>
<td>0.08</td>
</tr>
<tr>
<td>2.72</td>
<td>0.05</td>
</tr>
<tr>
<td>2.77</td>
<td>0.03</td>
</tr>
<tr>
<td>2.80</td>
<td>0.02</td>
</tr>
<tr>
<td>2.82</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>2.83</strong></td>
<td><strong>0.00</strong></td>
</tr>
</tbody>
</table>

Total Respending = 1.83
Network Model of Currency Flow

Respending over N:

\[ \rho_N = \frac{\sum_{i=1}^{n} c_i}{\text{Total Spending}} \]

- Respending over N is the average respending rate of nodes in the network
- Recirculating currency by definition occurs among nodes in the network

<table>
<thead>
<tr>
<th>Total Value</th>
<th>Respending = 65%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.65</td>
</tr>
<tr>
<td>1.65</td>
<td>0.42</td>
</tr>
<tr>
<td>2.07</td>
<td>0.27</td>
</tr>
<tr>
<td>2.35</td>
<td>0.18</td>
</tr>
<tr>
<td>2.53</td>
<td>0.12</td>
</tr>
<tr>
<td>2.64</td>
<td>0.08</td>
</tr>
<tr>
<td>2.72</td>
<td>0.05</td>
</tr>
<tr>
<td>2.77</td>
<td>0.03</td>
</tr>
<tr>
<td>2.80</td>
<td>0.02</td>
</tr>
<tr>
<td>2.82</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>2.83</strong></td>
<td><strong>0.00</strong></td>
</tr>
</tbody>
</table>

Total Respending = 1.83

Initial Spending * Total Respending = Gross Output
Network Model of Currency Flow

Respending over N:

\[
\rho_N = \frac{\sum_{i=1}^{n} c_i}{\text{Total Spending}}
\]

- Respending over N is the average respending rate of nodes in the network
- Recirculating currency by definition occurs among nodes in the network

<table>
<thead>
<tr>
<th>Total Value</th>
<th>Respending = 65%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.65</td>
</tr>
<tr>
<td>1.65</td>
<td>0.42</td>
</tr>
<tr>
<td>2.07</td>
<td>0.27</td>
</tr>
<tr>
<td>2.35</td>
<td>0.18</td>
</tr>
<tr>
<td>2.53</td>
<td>0.12</td>
</tr>
<tr>
<td>2.64</td>
<td>0.08</td>
</tr>
<tr>
<td>2.72</td>
<td>0.05</td>
</tr>
<tr>
<td>2.77</td>
<td>0.03</td>
</tr>
<tr>
<td>2.80</td>
<td>0.02</td>
</tr>
<tr>
<td>2.82</td>
<td>0.01</td>
</tr>
<tr>
<td>2.83</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Gross Output
\[
\frac{\text{Gross Output}}{\text{Total Respending}} = \text{Initial Spending} = \text{GDP}
\]

Total Respending = 1.83
Network Model of Currency Flow

For a network $N$ over a period $p$:

$T_A = \{ t_1, t_2, t_3 \ldots t_a \}$

$T_B = \{ t_1, t_2, t_3 \ldots t_b \}$

ALTERNATIVE $\rho = X\%$

CONTROL $\rho = \text{US AVE}\%$
Network Model of Currency Flow

For a network $N$ over a period $p$:

Initial Spending

$T_A = \{ t_1, t_2, t_3 \ldots t_a \}$

$T_B = \{ t_1, t_2, t_3 \ldots t_b \}$

ALTERNATIVE $\rho = X\%$

CONTROL $\rho = \text{US AVE}\%$
Network Model of Currency Flow

For a network N over a period $\rho$:

Initial Spending

$T_A = \{t_1, t_2, t_3 \ldots t_a\}$

$T_B = \{t_1, t_2, t_3 \ldots t_b\}$

ALTERNATIVE $\rho = X\%$

CONTROL $\rho = \text{US AVE}\%$

$\Delta_{\text{GDP}} = \frac{\text{GO @ } \rho = X\%}{\text{Total Respending @ } \rho = \text{US AVE}\%} - \frac{\text{GO @ } \rho = \text{US AVE}\%}{\text{Total Respending @ } \rho = \text{US AVE}\%}$
Local Capacity: The ability of local supply to meet local demand

Local capacity inhibits growth from multiplier effects
Is potential growth from respending big enough to care about, given local capacity?
Is potential growth from respending big enough to care about, given local capacity?

- Responding rate among local retailers: $\mu = 0.52$, $sd = 0.09$
Is potential growth from respending big enough to care about, given local capacity?

- Respending rate among local retailers: $\mu = 0.52, \ sd = 0.09$
- Respending rate among local restaurants: $\mu = 0.71, \ sd = 0.10$
Is potential growth from respending big enough to care about, given local capacity?

- Respending rate among local retailers: $\mu = 0.52$, $sd = 0.09$
- Respending rate among local restaurants: $\mu = 0.71$, $sd = 0.10$
- Retailer industry mean: 0.33
Is potential growth from respending big enough to care about, given local capacity?

- Respending rate among local retailers: $\mu = 0.52$, sd = 0.09
- Respending rate among local restaurants: $\mu = 0.71$, sd = 0.10
- Retailer industry mean: 0.33
- Restaurant industry mean: 0.51
Is potential growth from respending big enough to care about, given local capacity?

- Respending rate among local retailers: $\mu = 0.52, \text{ sd } = 0.09$
- Respending rate among local restaurants: $\mu = 0.71, \text{ sd } = 0.10$
- Retailer industry mean: 0.33
- Restaurant industry mean: 0.51

BEA NIPA tables 2001-2014
Is potential growth from respending big enough to care about, given local capacity?

- Respending rate among local retailers: $\mu = 0.52, \; sd = 0.09$
- Respending rate among local restaurants: $\mu = 0.71, \; sd = 0.10$
- Retailer industry mean: 0.33
- Restaurant industry mean: 0.51

BEA NIPA tables 2001-2014

- Sum GDP for industries associated with retail goods
Is potential growth from respending big enough to care about, given local capacity?

- Respending rate among local retailers: $\mu = 0.52$, $sd = 0.09$
- Respending rate among local restaurants: $\mu = 0.71$, $sd = 0.10$
- Retailer industry mean: 0.33
- Restaurant industry mean: 0.51

BEA NIPA tables 2001-2014

- Sum GDP for industries associated with retail goods
- Sum GDP for industries associated with food and beverage service
Is potential growth from respending big enough to care about, given local capacity?

- Respending rate among local retailers: $\mu = 0.52, \ sd = 0.09$
- Respending rate among local restaurants: $\mu = 0.71, \ sd = 0.10$
- Retailer industry mean: 0.33
- Restaurant industry mean: 0.51

BEA NIPA tables 2001-2014

- Sum GDP for industries associated with retail goods
- Sum GDP for industries associated with food and beverage service

Parameters:
Is potential growth from respending big enough to care about, given local capacity?

- Responding rate among local retailers: $\mu = 0.52$, $sd = 0.09$
- Responding rate among local restaurants: $\mu = 0.71$, $sd = 0.10$
- Retailer industry mean: 0.33
- Restaurant industry mean: 0.51

BEA NIPA tables 2001-2014

- Sum GDP for industries associated with retail goods
- Sum GDP for industries associated with food and beverage service

Parameters:

- Vary local capacity from industry mean to local (higher) mean
Is potential growth from respending big enough to care about, given local capacity?

- Respending rate among local retailers: $\mu = 0.52, \ sd = 0.09$
- Respending rate among local restaurants: $\mu = 0.71, \ sd = 0.10$
- Retailer industry mean: 0.33
- Restaurant industry mean: 0.51

**BEA NIPA tables 2001-2014**

- Sum GDP for industries associated with retail goods
- Sum GDP for industries associated with food and beverage service

**Parameters:**

- Vary local capacity from industry mean to local (higher) mean
- Vary participation from 10%-100% of population
Is potential growth from respending big enough to care about, given local capacity?

- Respending rate among local retailers: $\mu = 0.52$, $sd = 0.09$
- Respending rate among local restaurants: $\mu = 0.71$, $sd = 0.10$
- Retailer industry mean: 0.33
- Restaurant industry mean: 0.51

BEA NIPA tables 2001-2014

- Sum GDP for industries associated with retail goods
- Sum GDP for industries associated with food and beverage service

Parameters:

- Vary local capacity from industry mean to local (higher) mean
- Vary participation from 10%-100% of population
- Convert growth from respending to 2001 dollars at 7% dr
Participation and Capacity exert equal influence on the model (coded that way)

Failure mean: 48% capacity and participation      Success mean: 72% capacity and participation

Welch Two Sample t-test

data:  cap by flag
t = -68.492, df = 6971.5, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-2.41711 -2.28260
sample estimates:
mean in group 0 mean in group 1
 4.845442    7.195297

Welch Two Sample t-test

data:  part by flag
t = -68.492, df = 6971.5, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-2.41711 -2.28260
sample estimates:
mean in group 0 mean in group 1
 4.845442    7.195297
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>[1]</td>
<td>&quot;Illinois state total&quot;</td>
</tr>
<tr>
<td>[2]</td>
<td>&quot;Nevada state total&quot;</td>
</tr>
<tr>
<td>[3]</td>
<td>&quot;Utah state total&quot;</td>
</tr>
<tr>
<td>[4]</td>
<td>&quot;Michigan state total&quot;</td>
</tr>
<tr>
<td>[5]</td>
<td>&quot;Arkansas state total&quot;</td>
</tr>
<tr>
<td>[6]</td>
<td>&quot;Indiana state total&quot;</td>
</tr>
<tr>
<td>[7]</td>
<td>&quot;Mississippi state total&quot;</td>
</tr>
<tr>
<td>[8]</td>
<td>&quot;North Dakota state total&quot;</td>
</tr>
<tr>
<td>[9]</td>
<td>&quot;Hawaii state total&quot;</td>
</tr>
<tr>
<td>[10]</td>
<td>&quot;Delaware state total&quot;</td>
</tr>
<tr>
<td>[11]</td>
<td>&quot;Kansas state total&quot;</td>
</tr>
<tr>
<td>[12]</td>
<td>&quot;Nebraska state total&quot;</td>
</tr>
<tr>
<td>[13]</td>
<td>&quot;Kentucky state total&quot;</td>
</tr>
<tr>
<td>[14]</td>
<td>&quot;Texas state total&quot;</td>
</tr>
<tr>
<td>[15]</td>
<td>&quot;Washington state total&quot;</td>
</tr>
<tr>
<td>[16]</td>
<td>&quot;Wisconsin state total&quot;</td>
</tr>
<tr>
<td>[17]</td>
<td>&quot;West Virginia state total&quot;</td>
</tr>
<tr>
<td>[18]</td>
<td>&quot;Missouri state total&quot;</td>
</tr>
<tr>
<td>[19]</td>
<td>&quot;Minnesota state total&quot;</td>
</tr>
<tr>
<td>[20]</td>
<td>&quot;Iowa state total&quot;</td>
</tr>
<tr>
<td>[21]</td>
<td>&quot;Montana state total&quot;</td>
</tr>
<tr>
<td>[22]</td>
<td>&quot;Virginia state total&quot;</td>
</tr>
<tr>
<td>[23]</td>
<td>&quot;Vermont state total&quot;</td>
</tr>
<tr>
<td>[24]</td>
<td>&quot;Florida state total&quot;</td>
</tr>
<tr>
<td>[25]</td>
<td>&quot;Arizona state total&quot;</td>
</tr>
<tr>
<td>[26]</td>
<td>&quot;Massachusetts state total&quot;</td>
</tr>
<tr>
<td>[27]</td>
<td>&quot;Tennessee state total&quot;</td>
</tr>
<tr>
<td>[28]</td>
<td>&quot;Oklahoma state total&quot;</td>
</tr>
<tr>
<td>[29]</td>
<td>&quot;Ohio state total&quot;</td>
</tr>
<tr>
<td>[30]</td>
<td>&quot;Oregon state total&quot;</td>
</tr>
<tr>
<td>[31]</td>
<td>&quot;Maryland state total&quot;</td>
</tr>
<tr>
<td>[32]</td>
<td>&quot;South Carolina state total&quot;</td>
</tr>
<tr>
<td>[33]</td>
<td>&quot;California state total&quot;</td>
</tr>
<tr>
<td>[34]</td>
<td>&quot;Wyoming state total&quot;</td>
</tr>
<tr>
<td>[35]</td>
<td>&quot;Idaho state total&quot;</td>
</tr>
<tr>
<td>[36]</td>
<td>&quot;Georgia state total&quot;</td>
</tr>
<tr>
<td>[37]</td>
<td>&quot;Pennsylvania state total&quot;</td>
</tr>
<tr>
<td>[38]</td>
<td>&quot;Alabama state total&quot;</td>
</tr>
<tr>
<td>[39]</td>
<td>&quot;New Hampshire state total&quot;</td>
</tr>
<tr>
<td>[40]</td>
<td>&quot;Rhode Island state total&quot;</td>
</tr>
<tr>
<td>[41]</td>
<td>&quot;Maine state total&quot;</td>
</tr>
<tr>
<td>[42]</td>
<td>&quot;North Carolina state total&quot;</td>
</tr>
<tr>
<td>[43]</td>
<td>&quot;New York state total&quot;</td>
</tr>
<tr>
<td>[44]</td>
<td>&quot;New Jersey state total&quot;</td>
</tr>
<tr>
<td>[45]</td>
<td>&quot;District of Columbia state total&quot;</td>
</tr>
<tr>
<td>[46]</td>
<td>&quot;Colorado state total&quot;</td>
</tr>
<tr>
<td>[47]</td>
<td>&quot;New Mexico state total&quot;</td>
</tr>
<tr>
<td>[48]</td>
<td>&quot;Connecticut state total&quot;</td>
</tr>
<tr>
<td>[49]</td>
<td>&quot;Louisiana state total&quot;</td>
</tr>
<tr>
<td>[50]</td>
<td>&quot;South Dakota state total&quot;</td>
</tr>
</tbody>
</table>

Alaska is missing - don’t ask
Hurricane Disaster Relief
Table 1.

Supplemental Appropriations Related to the 2005 Gulf Coast Hurricanes, by Agency or Department, as of July 2007

(Billions of dollars)

<table>
<thead>
<tr>
<th>Agency or Department</th>
<th>Appropriations¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Emergency Management Agency,</td>
<td></td>
</tr>
<tr>
<td>Disaster Relief Fund</td>
<td>45.3</td>
</tr>
<tr>
<td>Department of Housing and Urban Development,</td>
<td></td>
</tr>
<tr>
<td>Community Development Block Grants</td>
<td>16.7</td>
</tr>
<tr>
<td>Department of Defense</td>
<td>9.4</td>
</tr>
<tr>
<td>Army Corps of Engineers</td>
<td>8.4</td>
</tr>
<tr>
<td>Department of Transportation</td>
<td>4.4</td>
</tr>
<tr>
<td>Department of Education</td>
<td>2.0</td>
</tr>
<tr>
<td>Small Business Administration</td>
<td>1.6</td>
</tr>
<tr>
<td>Federal Emergency Management Agency,</td>
<td></td>
</tr>
<tr>
<td>Community Disaster Loans</td>
<td>1.3</td>
</tr>
<tr>
<td>Department of Veterans Affairs</td>
<td>1.2</td>
</tr>
<tr>
<td>Department of Agriculture</td>
<td>1.0</td>
</tr>
<tr>
<td>Other Department of Homeland Security</td>
<td>0.8</td>
</tr>
<tr>
<td>Department of Health and Human Services</td>
<td>0.7</td>
</tr>
<tr>
<td>Other Agencies</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>94.8</strong></td>
</tr>
</tbody>
</table>

Source: Congressional Budget Office.

Note: Numbers may not sum to the total because of rounding.

Stimulating Business:

- The Small Business Administration (SBA) has approved more than $10.3 billion in disaster loans to homeowners, renters and business owners in the Gulf Coast states affected by the hurricanes. SBA has completed damage assessments on 99 percent of applications submitted and it has rendered decisions on more than 99 percent of the loan applications for businesses, homeowners and renters.

More than 22,000 (of 154,000 total) loans have gone to small business owners to the tune of $2.4 billion.

- In Louisiana: 91,345 disaster loans were approved for $6.4 billion; 78,364 home loans were approved for $5 billion; 12,981 business disaster loans were approved for $1.4 billion.
- In Mississippi: 34,937 disaster loans were approved for $2.5 billion; 30,473 home loans were approved for $2 billion; 4,464 business disaster loans were approved for $500 million.
Small Business Administration
Following the hurricanes, the Small Business Administration received about $1 billion in supplemental appropriations to make direct loans to individual homeowners and businesses located in areas affected by the storms. (In addition, about $550 million was provided for administrative expenses.) Of the 422,700 loan applications that SBA received, the agency approved about 119,000 of them, for an aggregate loan value of $6.9 billion.9

Using information from SBA, CBO estimates that, as of July 2007, about $1.0 billion in approved loans remains to be disbursed. By the end of 2007, CBO estimates, SBA will have spent about half of the funding it received for administrative expenses related to the hurricanes.
Hypothetical Disaster Relief Fund Simulation
Hypothetical Disaster Relief Fund Simulation

1. Declare the 22 affected counties an ‘Economic Recovery Zone’
Hypothetical Disaster Relief Fund Simulation

1. Declare the 22 affected counties an ‘Economic Recovery Zone’
2. Disperse $1b evenly among the population of 22 affected counties
Hypothetical Disaster Relief Fund Simulation

1. Declare the 22 affected counties an ‘Economic Recovery Zone’

2. Disperse $1b evenly among the population of 22 affected counties
   • People receive an ERZ debit card with the funds (similar to EBT)
Hypothetical Disaster Relief Fund Simulation

1. Declare the 22 affected counties an ‘Economic Recovery Zone’

2. Disperse $1b evenly among the population of 22 affected counties
   • People receive an ERZ debit card with the funds (similar to EBT)

3. People can spend the funds at any business in the ERZ
Hypothetical Disaster Relief Fund Simulation

1. Declare the 22 affected counties an ‘Economic Recovery Zone’

2. Disperse $1b evenly among the population of 22 affected counties
   • People receive an ERZ debit card with the funds (similar to EBT)

3. People can spend the funds at any business in the ERZ
   • Funds transfer to the ERZ account of the business
Hypothetical Disaster Relief Fund Simulation

1. Declare the 22 affected counties an ‘Economic Recovery Zone’

2. Disperse $1b evenly among the population of 22 affected counties
   • People receive an ERZ debit card with the funds (similar to EBT)

3. People can spend the funds at any business in the ERZ
   • Funds transfer to the ERZ account of the business

4. The business uses ERZ dollars on expenses
Hypothetical Disaster Relief Fund Simulation

1. Declare the 22 affected counties an ‘Economic Recovery Zone’

2. Disperse $1b evenly among the population of 22 affected counties
   • People receive an ERZ debit card with the funds (similar to EBT)

3. People can spend the funds at any business in the ERZ
   • Funds transfer to the ERZ account of the business

4. The business uses ERZ dollars on expenses
   • by purchasing from suppliers in the ERZ
Hypothetical Disaster Relief Fund Simulation

1. Declare the 22 affected counties an ‘Economic Recovery Zone’

2. Disperse $1b evenly among the population of 22 affected counties
   • People receive an ERZ debit card with the funds (similar to EBT)

3. People can spend the funds at any business in the ERZ
   • Funds transfer to the ERZ account of the business

4. The business uses ERZ dollars on expenses
   • by purchasing from suppliers in the ERZ
   • by paying employees in the ERZ
Hypothetical Disaster Relief Fund Simulation

1. Declare the 22 affected counties an ‘Economic Recovery Zone’

2. Disperse $1b evenly among the population of 22 affected counties
   • People receive an ERZ debit card with the funds (similar to EBT)

3. People can spend the funds at any business in the ERZ
   • Funds transfer to the ERZ account of the business

4. The business uses ERZ dollars on expenses
   • by purchasing from suppliers in the ERZ
   • by paying employees in the ERZ

We introduce extra money into the economic network that cannot leave
$1 billion Disaster Relief Fund in 22 Katrina affected counties in LA

Log(BCR)

Year

2005  2010

county
Ascension, LA
Assumption, LA
East Baton Rouge, LA
Iberia, LA
Iberville, LA
Jefferson, LA
Lafourche, LA
Livingston, LA
Orleans, LA
Plaquemines, LA
St. Bernard, LA
St. Charles, LA
St. Helena, LA
St. James, LA
St. John the Baptist, LA
St. Martin, LA
St. Mary, LA
St. Tammany, LA
Tangipahoa, LA
Terrebonne, LA
Washington, LA
West Baton Rouge, LA
BCR from $1 billion @ 1 cent increase in responding %

BCR from fund responding in 2001 USD millions

Year

2002 2003 2004
Strength of the Multiplier Effect

Total Multiplier Effect ($)

Respecting Rate (%)
BIG TAKEAWAY ≠
BIG TAKEAWAY ≠ multipliers make you grow at 98,687,483%
BIG TAKEAWAY ≠ multipliers make you grow at 98,687,483%
BIG TAKEAWAY ≠ multipliers make you grow at 98,687,483%
BIG TAKEAWAY  =

nutrient co-limitation
BIG TAKEAWAY = The current US respending rate inhibits growth
Financial Instruments
Transaction sets for network N

\[ T_A = \{ t_{a1}, t_{a2}, t_{a3} \ldots t_{am} \} \]

\[ T_B = \{ t_{b1}, t_{b2}, t_{b3} \ldots t_{bn} \} \]

\[ T_C = \{ t_{c1}, t_{c2}, t_{c3} \ldots t_{cp} \} \]
Transaction sets for network N

\[ T_A = \{ t_{a1}, t_{a2}, t_{a3} \ldots t_{am} \} \]

\[ T_B = \{ t_{b1}, t_{b2}, t_{b3} \ldots t_{bn} \} \]

\[ T_C = \{ t_{c1}, t_{c2}, t_{c3} \ldots t_{cp} \} \]

<table>
<thead>
<tr>
<th>Total Value</th>
<th>Respending (65%)</th>
<th>Spent</th>
<th>Round</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.65</td>
<td>0.35</td>
<td>1</td>
</tr>
<tr>
<td>1.65</td>
<td>0.42</td>
<td>0.23</td>
<td>2</td>
</tr>
<tr>
<td>2.07</td>
<td>0.27</td>
<td>0.15</td>
<td>3</td>
</tr>
<tr>
<td>2.35</td>
<td>0.18</td>
<td>0.09</td>
<td>4</td>
</tr>
<tr>
<td>2.53</td>
<td>0.12</td>
<td>0.06</td>
<td>5</td>
</tr>
<tr>
<td>2.64</td>
<td>0.08</td>
<td>0.04</td>
<td>6</td>
</tr>
<tr>
<td>2.72</td>
<td>0.05</td>
<td>0.03</td>
<td>7</td>
</tr>
<tr>
<td>2.77</td>
<td>0.03</td>
<td>0.02</td>
<td>8</td>
</tr>
<tr>
<td>2.80</td>
<td>0.02</td>
<td>0.01</td>
<td>9</td>
</tr>
<tr>
<td>2.82</td>
<td>0.01</td>
<td>0.01</td>
<td>10</td>
</tr>
<tr>
<td>2.83</td>
<td>0.00</td>
<td>0.01</td>
<td>11</td>
</tr>
</tbody>
</table>

**Total Respending** = 1.83

\[ \text{sum(spent } \times \text{ round)} \over \# \text{ of rounds} = 2.83 \]
Transaction sets for network N

\[ T_A = \{ t_{a1}, t_{a2}, t_{a3} \ldots t_{am} \} \]

\[ T_B = \{ t_{b1}, t_{b2}, t_{b3} \ldots t_{bn} \} \]

\[ T_C = \{ t_{c1}, t_{c2}, t_{c3} \ldots t_{cp} \} \]

Currency set for N:

\[ C_N = \{ c_1, c_2, c_3 \ldots c_q \} \]

<table>
<thead>
<tr>
<th>Total Value</th>
<th>Respending = 65%</th>
<th>Spent</th>
<th>Round</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.65</td>
<td>0.35</td>
<td>1</td>
</tr>
<tr>
<td>1.65</td>
<td>0.42</td>
<td>0.23</td>
<td>2</td>
</tr>
<tr>
<td>2.07</td>
<td>0.27</td>
<td>0.15</td>
<td>3</td>
</tr>
<tr>
<td>2.35</td>
<td>0.18</td>
<td>0.09</td>
<td>4</td>
</tr>
<tr>
<td>2.53</td>
<td>0.12</td>
<td>0.06</td>
<td>5</td>
</tr>
<tr>
<td>2.64</td>
<td>0.08</td>
<td>0.04</td>
<td>6</td>
</tr>
<tr>
<td>2.72</td>
<td>0.05</td>
<td>0.03</td>
<td>7</td>
</tr>
<tr>
<td>2.77</td>
<td>0.03</td>
<td>0.02</td>
<td>8</td>
</tr>
<tr>
<td>2.80</td>
<td>0.02</td>
<td>0.01</td>
<td>9</td>
</tr>
<tr>
<td>2.82</td>
<td>0.01</td>
<td>0.01</td>
<td>10</td>
</tr>
<tr>
<td>2.83</td>
<td>0.00</td>
<td>0.01</td>
<td>11</td>
</tr>
</tbody>
</table>

Total Respending = 1.83

\[
\frac{\text{sum}(\text{spent} \times \text{round})}{\text{# of rounds}} = 2.83
\]
Transaction sets for network N

\[ T_A = \{ t_{a1}, t_{a2}, t_{a3}, \ldots t_{am} \} \]

\[ T_B = \{ t_{b1}, t_{b2}, t_{b3}, \ldots t_{bn} \} \]

\[ T_C = \{ t_{c1}, t_{c2}, t_{c3}, \ldots t_{cp} \} \]

Currency set for N:

\[ C_N = \{ c_1, c_2, c_3, \ldots c_q \} \]

Transactions for each \( c_i \in C_N \):

\[ T^o c_i = \{ t_{i1}, t_{i2}, t_{i3}, \ldots t_{ir} \} \]

<table>
<thead>
<tr>
<th>Total Value</th>
<th>Respending = 65%</th>
<th>Spent</th>
<th>Round</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.65</td>
<td>0.35</td>
<td>1</td>
</tr>
<tr>
<td>1.65</td>
<td>0.42</td>
<td>0.23</td>
<td>2</td>
</tr>
<tr>
<td>2.07</td>
<td>0.27</td>
<td>0.15</td>
<td>3</td>
</tr>
<tr>
<td>2.35</td>
<td>0.18</td>
<td>0.09</td>
<td>4</td>
</tr>
<tr>
<td>2.53</td>
<td>0.12</td>
<td>0.06</td>
<td>5</td>
</tr>
<tr>
<td>2.64</td>
<td>0.08</td>
<td>0.04</td>
<td>6</td>
</tr>
<tr>
<td>2.72</td>
<td>0.05</td>
<td>0.03</td>
<td>7</td>
</tr>
<tr>
<td>2.77</td>
<td>0.03</td>
<td>0.02</td>
<td>8</td>
</tr>
<tr>
<td>2.80</td>
<td>0.02</td>
<td>0.01</td>
<td>9</td>
</tr>
<tr>
<td>2.82</td>
<td>0.01</td>
<td>0.01</td>
<td>10</td>
</tr>
<tr>
<td>2.83</td>
<td>0.00</td>
<td>0.01</td>
<td>11</td>
</tr>
</tbody>
</table>

Total Respending = 1.83

\[ \text{sum(spent} \times \text{round}) \quad \frac{\# \text{of rounds}}{11} = 2.83 \]
Transaction sets for network $N$

$T_A = \{ t_{a1}, t_{a2}, t_{a3} \ldots t_{am} \}$

$T_B = \{ t_{b1}, t_{b2}, t_{b3} \ldots t_{bn} \}$

$T_C = \{ t_{c1}, t_{c2}, t_{c3} \ldots t_{cp} \}$

Currency set for $N$:

$C_N = \{ c_1, c_2, c_3 \ldots c_q \}$

Transactions for each $c_i \in C_N$:

$T^o c_i = \{ t_{i1}, t_{i2}, t_{i3} \ldots t_{ir} \}$

Node $n$ in $N$ spends budget $B$:

$B_n = \{ c_1, c_2, c_3 \ldots c_b \}$

<table>
<thead>
<tr>
<th>Total Value</th>
<th>Respending = 65%</th>
<th>Spent</th>
<th>Round</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.65</td>
<td>0.35</td>
<td>1</td>
</tr>
<tr>
<td>1.65</td>
<td>0.42</td>
<td>0.23</td>
<td>2</td>
</tr>
<tr>
<td>2.07</td>
<td>0.27</td>
<td>0.15</td>
<td>3</td>
</tr>
<tr>
<td>2.35</td>
<td>0.18</td>
<td>0.09</td>
<td>4</td>
</tr>
<tr>
<td>2.53</td>
<td>0.12</td>
<td>0.06</td>
<td>5</td>
</tr>
<tr>
<td>2.64</td>
<td>0.08</td>
<td>0.04</td>
<td>6</td>
</tr>
<tr>
<td>2.72</td>
<td>0.05</td>
<td>0.03</td>
<td>7</td>
</tr>
<tr>
<td>2.77</td>
<td>0.03</td>
<td>0.02</td>
<td>8</td>
</tr>
<tr>
<td>2.80</td>
<td>0.02</td>
<td>0.01</td>
<td>9</td>
</tr>
<tr>
<td>2.82</td>
<td>0.01</td>
<td>0.01</td>
<td>10</td>
</tr>
<tr>
<td><strong>2.83</strong></td>
<td><strong>0.00</strong></td>
<td><strong>0.01</strong></td>
<td><strong>11</strong></td>
</tr>
</tbody>
</table>

Total Respending = 1.83

$\frac{\text{sum(spent} \times \text{round})}{\text{# of rounds}} = 2.83$
Transaction sets for network $N$

$$T_A = \{ t_{a1}, t_{a2}, t_{a3} ... t_{am} \}$$

$$T_B = \{ t_{b1}, t_{b2}, t_{b3} ... t_{bn} \}$$

$$T_C = \{ t_{c1}, t_{c2}, t_{c3} ... t_{cp} \}$$

<table>
<thead>
<tr>
<th>Total Value</th>
<th>Respending = 65%</th>
<th>Spent</th>
<th>Round</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.65</td>
<td>0.35</td>
<td>1</td>
</tr>
<tr>
<td>1.65</td>
<td>0.42</td>
<td>0.23</td>
<td>2</td>
</tr>
<tr>
<td>2.07</td>
<td>0.27</td>
<td>0.15</td>
<td>3</td>
</tr>
<tr>
<td>2.35</td>
<td>0.18</td>
<td>0.09</td>
<td>4</td>
</tr>
<tr>
<td>2.53</td>
<td>0.12</td>
<td>0.06</td>
<td>5</td>
</tr>
<tr>
<td>2.64</td>
<td>0.08</td>
<td>0.04</td>
<td>6</td>
</tr>
<tr>
<td>2.72</td>
<td>0.05</td>
<td>0.03</td>
<td>7</td>
</tr>
<tr>
<td>2.77</td>
<td>0.03</td>
<td>0.02</td>
<td>8</td>
</tr>
<tr>
<td>2.80</td>
<td>0.02</td>
<td>0.01</td>
<td>9</td>
</tr>
<tr>
<td>2.82</td>
<td>0.01</td>
<td>0.01</td>
<td>10</td>
</tr>
<tr>
<td>2.83</td>
<td>0.00</td>
<td>0.01</td>
<td>11</td>
</tr>
</tbody>
</table>

Total Respending = 1.83

$$\text{sum}(\text{spent} \times \text{round}) = 2.83$$

Currency set for $N$:

$$C_N = \{ c_1, c_2, c_3 ... c_q \}$$

Transactions for each $c_i \in C_N$:

$$T \circ c_i = \{ t_{i1}, t_{i2}, t_{i3} ... t_{ir} \}$$

Node $n$ in $N$ spends budget $B$:

$$B_n = \{ c_1, c_2, c_3 ... c_b \}$$

Responding for node $n$:

$$\frac{\sum(T \circ B_n)}{\sum(B_n)}$$
Investor with budget $I$:

\[ I_n = \{ c_1, c_2, c_3, \ldots, c_i \} \]

Responding for node $n$:

\[
\frac{\sum(T \circ I_n)}{\sum(I_n)}
\]
Investor with budget $I_n$:

$$I_n = \{ c_1, c_2, c_3 \ldots c_i \}$$

Responding for node $n$:

$$\frac{\Sigma(T \circ I_n)}{\Sigma(I_n)}$$

Expected growth for $I$:

$$\Sigma(I_n) \times \text{Total Multiplier[us ave]}$$

Added growth for $I$:

$$\frac{\Sigma(T \circ I_n)}{\Sigma(I_n)}$$

$\text{Expected growth}$
Investor with budget $I$:  

$I_n = \{ c_1, c_2, c_3 \ldots c_i \}$

Responing for node $n$:  

$$\frac{\sum(T \circ I_n)}{\sum(I_n)}$$

Expected growth for $I$:  

$$\sum(I_n) \times \text{Total Multiplier [us ave]}$$

Added growth for $I$:  

$$\frac{\sum(T \circ I_n)}{\sum(I_n)} \quad \text{ Expected growth}$$

Added growth per $c \in C_N$:  

$$\frac{\text{Added growth}_I}{\sum(C_n)}$$
Investor with budget $I$:

$I_n = \{ c_1, c_2, c_3 \ldots c_i \}$

Respending for node $n$:

$$\frac{\sum(T \circ I_n)}{\sum(I_n)}$$

Added growth per $c \in C_N$:

$$\frac{\sum(B_n) \times \text{Added growth per } c}{\sum(C_n)}$$

Expected growth for $I$:

$$\sum(I_n) \times \text{Total Multiplier}[\text{us ave}]$$

Added growth for $I$:

$$\frac{\sum(T \circ I_n)}{\sum(I_n)} \quad \text{— Expected growth}$$

Cost to borrower $n \in N$:

$$\sum(B_n) \times \text{Added growth per } c$$
Investor with budget $I$: 

$$I_n = \{ c_1, c_2, c_3 \ldots c_i \}$$

Respecting for node $n$:

$$\frac{\Sigma(T \circ I_n)}{\Sigma(I_n)}$$

Expected growth for $I$:

$$\Sigma(I_n) * \text{Total Multiplier[us ave]}$$

Added growth for $I$:

$$\frac{\Sigma(T \circ I_n)}{\Sigma(I_n)} \quad \text{— Expected growth}$$

Added growth per $c \in C_N$:

$$\frac{\text{Added growth}_I}{\Sigma(C_n)}$$

Cost to borrower $n \in N$:

$$\Sigma(B_n) * \text{Added growth per } c$$

Pool investment returns and borrowing costs across the network to increase equity
BCR Ratio of $1 with no investment return

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.651</td>
<td>0.00</td>
<td>0.01</td>
<td>0.03</td>
<td>0.06</td>
<td>0.12</td>
<td>0.24</td>
<td>0.46</td>
<td>0.87</td>
<td>1.65</td>
<td>3.11</td>
</tr>
<tr>
<td>0.652</td>
<td>0.01</td>
<td>0.02</td>
<td>0.06</td>
<td>0.12</td>
<td>0.25</td>
<td>0.49</td>
<td>0.94</td>
<td>1.79</td>
<td>3.38</td>
<td>6.40</td>
</tr>
<tr>
<td>0.653</td>
<td>0.01</td>
<td>0.03</td>
<td>0.09</td>
<td>0.19</td>
<td>0.38</td>
<td>0.75</td>
<td>1.44</td>
<td>2.75</td>
<td>5.21</td>
<td>9.88</td>
</tr>
<tr>
<td>0.654</td>
<td>0.02</td>
<td>0.05</td>
<td>0.12</td>
<td>0.26</td>
<td>0.53</td>
<td>1.03</td>
<td>1.98</td>
<td>3.79</td>
<td>7.20</td>
<td>13.67</td>
</tr>
<tr>
<td>0.655</td>
<td>0.02</td>
<td>0.06</td>
<td>0.15</td>
<td>0.33</td>
<td>0.66</td>
<td>1.29</td>
<td>2.50</td>
<td>4.78</td>
<td>9.11</td>
<td>17.34</td>
</tr>
<tr>
<td>0.656</td>
<td>0.02</td>
<td>0.07</td>
<td>0.18</td>
<td>0.39</td>
<td>0.80</td>
<td>1.56</td>
<td>3.02</td>
<td>5.80</td>
<td>11.09</td>
<td>21.15</td>
</tr>
<tr>
<td>0.657</td>
<td>0.03</td>
<td>0.09</td>
<td>0.22</td>
<td>0.48</td>
<td>0.98</td>
<td>1.93</td>
<td>3.74</td>
<td>7.20</td>
<td>13.79</td>
<td>26.36</td>
</tr>
<tr>
<td>0.658</td>
<td>0.04</td>
<td>0.10</td>
<td>0.27</td>
<td>0.58</td>
<td>1.17</td>
<td>2.31</td>
<td>4.49</td>
<td>8.65</td>
<td>16.60</td>
<td>31.79</td>
</tr>
<tr>
<td>0.659</td>
<td>0.04</td>
<td>0.12</td>
<td>0.30</td>
<td>0.65</td>
<td>1.32</td>
<td>2.61</td>
<td>5.08</td>
<td>9.80</td>
<td>18.85</td>
<td>36.20</td>
</tr>
<tr>
<td>0.66</td>
<td>0.04</td>
<td>0.13</td>
<td>0.33</td>
<td>0.72</td>
<td>1.47</td>
<td>2.91</td>
<td>5.68</td>
<td>11.00</td>
<td>21.20</td>
<td>40.79</td>
</tr>
</tbody>
</table>

BCR Ratio of $1 with 50% investment return

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.651</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
<td>0.02</td>
<td>0.02</td>
<td>0.04</td>
<td>0.05</td>
<td>0.08</td>
<td>0.11</td>
<td>0.16</td>
</tr>
<tr>
<td>0.652</td>
<td>0.00</td>
<td>0.01</td>
<td>0.02</td>
<td>0.03</td>
<td>0.05</td>
<td>0.07</td>
<td>0.11</td>
<td>0.16</td>
<td>0.23</td>
<td>0.32</td>
</tr>
<tr>
<td>0.653</td>
<td>0.01</td>
<td>0.01</td>
<td>0.03</td>
<td>0.05</td>
<td>0.07</td>
<td>0.11</td>
<td>0.16</td>
<td>0.24</td>
<td>0.35</td>
<td>0.50</td>
</tr>
<tr>
<td>0.654</td>
<td>0.01</td>
<td>0.02</td>
<td>0.04</td>
<td>0.06</td>
<td>0.10</td>
<td>0.15</td>
<td>0.22</td>
<td>0.33</td>
<td>0.47</td>
<td>0.68</td>
</tr>
<tr>
<td>0.655</td>
<td>0.01</td>
<td>0.02</td>
<td>0.05</td>
<td>0.08</td>
<td>0.13</td>
<td>0.19</td>
<td>0.28</td>
<td>0.42</td>
<td>0.60</td>
<td>0.87</td>
</tr>
<tr>
<td>0.656</td>
<td>0.01</td>
<td>0.03</td>
<td>0.06</td>
<td>0.10</td>
<td>0.15</td>
<td>0.24</td>
<td>0.35</td>
<td>0.51</td>
<td>0.74</td>
<td>1.07</td>
</tr>
<tr>
<td>0.657</td>
<td>0.01</td>
<td>0.03</td>
<td>0.07</td>
<td>0.11</td>
<td>0.18</td>
<td>0.28</td>
<td>0.41</td>
<td>0.60</td>
<td>0.87</td>
<td>1.26</td>
</tr>
<tr>
<td>0.658</td>
<td>0.02</td>
<td>0.04</td>
<td>0.08</td>
<td>0.14</td>
<td>0.22</td>
<td>0.34</td>
<td>0.50</td>
<td>0.73</td>
<td>1.06</td>
<td>1.54</td>
</tr>
<tr>
<td>0.659</td>
<td>0.02</td>
<td>0.05</td>
<td>0.09</td>
<td>0.16</td>
<td>0.25</td>
<td>0.38</td>
<td>0.56</td>
<td>0.83</td>
<td>1.21</td>
<td>1.74</td>
</tr>
<tr>
<td>0.66</td>
<td>0.02</td>
<td>0.05</td>
<td>0.10</td>
<td>0.17</td>
<td>0.28</td>
<td>0.42</td>
<td>0.63</td>
<td>0.92</td>
<td>1.35</td>
<td>1.95</td>
</tr>
</tbody>
</table>
BCR of $1 with 50% investment return

Investment Year

BCR (0.7 d\text{r})

responding rate

0.66

0.659

0.658

0.657

0.656

0.655

0.654

0.653

0.652

0.651
Small increases in the responding rate generate significant growth
Small increases in the responding rate generate significant growth.

Growth still surpasses 7% annually after dispersing 50% to investors.
Small increases in the responding rate generate significant growth

Growth still surpasses 7% annually after dispersing 50% to investors

Potentially attractive financial instrument for:
Small increases in the responding rate generate significant growth.

Growth still surpasses 7% annually after dispersing 50% to investors.

Potentially attractive financial instrument for:

- Stimulus and disaster relief
- State and local government bond debt
- Private investment
- NGOs
Social networking technology allows individuals to track to the flow of currency at an unprecedented level.
Social networking technology allows individuals to track to the flow of currency at an unprecedented level.

Over time, we can estimate economic codependence:
Social networking technology allows individuals to track to the flow of currency at an unprecedented level.

Over time, we can estimate economic codependence:

When you buy from a vendor:
Social networking technology allows individuals to track to the flow of currency at an unprecedented level.

Over time, we can estimate **economic codependence**:

When you buy from a vendor:

- How likely are they to purchase goods or services from your business?
Social networking technology allows individuals to track to the flow of currency at an unprecedented level.

Over time, we can estimate economic codependence:

When you buy from a vendor:

• How likely are they to purchase goods or services from your business?
• How likely are the people they purchase from to purchase from you?
Social networking technology allows individuals to track to the flow of currency at an unprecedented level.

Over time, we can estimate economic codependence:

When you buy from a vendor:

- How likely are they to purchase goods or services from your business?
- How likely are the people they purchase from to purchase from you?

Provide consumers with new information.
Social networking technology allows individuals to track to the flow of currency at an unprecedented level.

Over time, we can estimate economic codependence:

When you buy from a vendor:

• How likely are they to purchase goods or services from your business?
• How likely are the people they purchase from to purchase from you?

Provide consumers with new information

Consumers change spending behavior to increase utility
Economic codependence is the degree to which the people one consumer spends money on in turn spend money on people who support the businesses of another consumer and vice versa.
Consumer choice logit model

\[ \eta = \text{price} + \text{quality} + \text{location} + \text{codependence} \]

Control has price, quality and location indicators
Treatment includes ranking of economic codependence
Consumer choice logit model

\[ \eta = \text{price} + \text{quality} + \text{location} + \text{codependence} \]

Control has price, quality and location indicators
Treatment includes ranking of economic codependence

Hypothesis:
Given two products of perceived equal cost, quality and convenience, consumers will choose the more economically dependent vendor.
Consumer choice logit model

\[ \eta = \text{price} + \text{quality} + \text{location} + \text{codependence} \]

Control has price, quality and location indicators
Treatment includes ranking of economic codependence

Hypothesis:
Given two products of perceived equal cost, quality and convenience, consumers will choose the more economically dependent vendor.

Short Term vs. Long Term:
Long term experiments let consumers experience the consequences of responding over several spending periods
Consumer choice logit model

\[ \eta = \text{price} + \text{quality} + \text{location} + \text{codependence} \]

Control has price, quality and location indicators
Treatment includes ranking of economic codependence

Hypothesis:
Given two products of perceived equal cost, quality and convenience, consumers will choose the more economically dependent vendor.

Short Term vs. Long Term:
Long term experiments let consumers experience the consequences of responding over several spending periods

Web-based app permits search optimization by economic dependence
QUESTIONS