Offshoring and Firm Overlap

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Motivation

- Offshoring features prominently in the public debate as well as the scientific research on international trade

- Recent contributions focus on the role of firm heterogeneity:
  - Antràs and Helpman (2004)
  - Egger, Kreickemeier and Wrona (2013)

- In heterogeneous firms models à la Melitz (2003) with fixed offshoring costs:
  - Firms self-select into offshoring
  - Direct link between firm size and offshoring status

- But considerable overlap in the data: firms with the same size (or productivity) have different offshoring intensities
# Motivation

## Table: Firm size and offshoring

<table>
<thead>
<tr>
<th>Size (IAB)</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>82.21</td>
<td>17.69</td>
</tr>
<tr>
<td>6-10</td>
<td>75.43</td>
<td>24.57</td>
</tr>
<tr>
<td>11-18</td>
<td>73.84</td>
<td>26.16</td>
</tr>
<tr>
<td>19-30</td>
<td>62.47</td>
<td>37.53</td>
</tr>
<tr>
<td>31-54</td>
<td>47.12</td>
<td>52.88</td>
</tr>
<tr>
<td>55-97</td>
<td>36.56</td>
<td>63.44</td>
</tr>
<tr>
<td>98-178</td>
<td>26.31</td>
<td>73.69</td>
</tr>
<tr>
<td>179-306</td>
<td>17.03</td>
<td>82.97</td>
</tr>
<tr>
<td>307-680</td>
<td>16.10</td>
<td>83.90</td>
</tr>
<tr>
<td>&gt; 680</td>
<td>6.76</td>
<td>93.24</td>
</tr>
<tr>
<td>Total</td>
<td>45.93</td>
<td>54.07</td>
</tr>
</tbody>
</table>

## Table: Nr. of tasks and offshoring

<table>
<thead>
<tr>
<th>Nr. tasks</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-9</td>
<td>82.91</td>
<td>17.09</td>
</tr>
<tr>
<td>10-12</td>
<td>76.65</td>
<td>23.35</td>
</tr>
<tr>
<td>13-14</td>
<td>68.00</td>
<td>32.00</td>
</tr>
<tr>
<td>15-16</td>
<td>56.86</td>
<td>43.14</td>
</tr>
<tr>
<td>17</td>
<td>52.36</td>
<td>47.64</td>
</tr>
<tr>
<td>18</td>
<td>30.77</td>
<td>69.23</td>
</tr>
<tr>
<td>19-22</td>
<td>45.44</td>
<td>54.56</td>
</tr>
<tr>
<td>23</td>
<td>24.92</td>
<td>75.08</td>
</tr>
<tr>
<td>24</td>
<td>16.69</td>
<td>83.31</td>
</tr>
<tr>
<td>&gt; 24</td>
<td>11.58</td>
<td>88.42</td>
</tr>
<tr>
<td>Total</td>
<td>69.29</td>
<td>30.71</td>
</tr>
</tbody>
</table>
Motivation

▶ Stylized facts show:
  ▶ subset of firms of each category engages in offshoring
  ▶ share increases in firm size/number of tasks

▶ In Melitz-type models overlap requires the draw of two (dependent) random variables (Davis and Harrigan, 2011; Harrigan and Reshef, *forthcoming*)

▶ So far missing: clean microfoundation of overlap
This paper

Theory

▶ *Tractable* model of offshoring and firm overlap
▶ New microfoundation: firms differ
  ▶ in the range of tasks they perform, and
  ▶ in the share of offshorable tasks
    $\implies$ Probability of offshoring increases in the number of tasks

Empirics

▶ Model-based estimation of key parameters
▶ Quantifying the welfare effects of offshoring
▶ Conducting counterfactual analysis
The model

Basic assumptions

- 2 countries, \( L \) (developed, source) and \( L^* \) (undeveloped, host)
- Consumers in both countries have identical CES preferences
- Monopolistic competition among single-product firms
- Production requires performance of different tasks, combined into a Cobb-Douglas technology

\[
q = \frac{z}{1-z} \exp \left[ \frac{1}{z} \int_0^z \ln x(i) \, di \right], \tag{1}
\]

- \( x(i) \) output for task \( i \), which equals labor input
- \( z \in (0, 1) \) firm-specific number of tasks
The model

Cost minimization

- Two modes of production:
  - $c^d = (1 - z)w$, if all tasks are performed at home
  - $c^o = (1 - z)w\kappa^s$, if share $s$ is performed offshore

Where:
- $\kappa \equiv \tau w^*/w$ is the effective wage differential

- Offshoring only attractive if $\kappa < 1$

- $1/\kappa^s$ is the marginal cost saving effect of offshoring
The model

Firm entry

- Entering requires an initial investment of \( f_e \) units of labor
- Investment gives single draw from a lottery
- Outcome is a technology tuple \((z, s)\)
  - \(z\): number of tasks,
    \[
    f_z(z) = k(1 - z)^{k-1}
    \]
  - \(s\): share of offshorable tasks,
    \[
    s \sim U(0, 1)
    \]
- After the lottery, firms only know \(z\) but are uninformed about \(s\)
The model

Firm entry

- Firms form expectations on $s$:
  - Probability of $s > 0$ is a positive function of $z$
  - For tractability, we set this probability equal to $z$

- Firms can invest $f$ units of labor into a fixed offshoring service, which provides information on the share $s$ of offshorable tasks

  $\Rightarrow$ **Intuition:** Firms have to go through an in-depth analysis of their offshoring potential

- At $\hat{z}$ a firm is indifferent between investing $f$ or not
The model

Illustration

\[ f_e \]

draw \((z, s)\) while only \(z\) is revealed

\[ z < \hat{z} \]

no investment, \(f = 0\)

\[ s = ? \]

\[ c^d = (1 - z)w \]

\[ p = \frac{\sigma}{\sigma - 1} c^d \]

\[ \pi = pq \]

\[ s = 0 \]

\[ c^d = (1 - z)w \]

\[ p = \frac{\sigma}{\sigma - 1} c^d \]

\[ \pi = pq - f \]

\[ s \geq 0 \]

\[ c^o = (1 - z)w_k^s \]

\[ p = \frac{\sigma}{\sigma - 1} c^o \]

\[ \pi = pq - f \]
The model

Equilibrium

- **Offshoring indifference condition (OC):**

\[
\Gamma_1 (\hat{\sigma}, \kappa) = \frac{\hat{\sigma}^{\sigma - 1}}{1 - \hat{\sigma}} \frac{k}{k - \sigma + 1} + \left\{ \frac{\hat{\sigma}^k}{1 - \hat{\sigma}} \left[ \frac{\sigma - 1}{k - \sigma + 1} - \hat{\sigma} \frac{\sigma - 2}{k - \sigma + 2} \right] - \frac{f_e}{f} \right\} \left[ \frac{\kappa^{1-\sigma} - 1}{(1 - \sigma) \ln \kappa} - 1 \right] = 0.
\]

→ establishes a negative link between \( \hat{\sigma} \) and \( \kappa \)

- **Labor market constraint (LC):**

\[
\Gamma_2 (\kappa, \hat{\sigma}) \equiv \kappa \left\{ \frac{\sigma + 1}{\sigma - 1} + \frac{2\sigma}{\sigma - 1} \frac{(1 - \sigma) \ln \kappa}{\kappa^{1-\sigma} - 1} \left[ \frac{k - \sigma + 2}{\hat{\sigma}^{k-\sigma+1} [1 + (1 - \hat{\sigma})(k - \sigma + 1)]} - 1 \right] \right\} - \frac{\tau L}{L^*} = 0.
\]

→ establishes a positive link between \( \hat{\sigma} \) and \( \kappa \)

- System of two equations which jointly determine a unique interior equilibrium with \( \hat{\sigma}, \kappa \in (0, 1) \)
Equilibrium values of $\hat{c}$ and $\kappa = \tau \psi^*$

Figure: Equilibrium values of $\hat{c}$ and $\kappa$
Comparative statics: increase in $f$

Figure: Equilibrium values of $\hat{c}$ and $\kappa$
Comparative statics: increase in $\tau$

Figure: Equilibrium values of $\hat{c}$ and $\kappa$
**Data source**

- 29 tasks from BIBB-BAuA 2006 survey
- Sample selection: large manufacturing firms (i.e., 4 employees)

**Table: Summary statistics**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offshoring</td>
<td>0.38</td>
<td>0.00</td>
<td>0.49</td>
</tr>
<tr>
<td>Nr. of tasks</td>
<td>13.98</td>
<td>14.00</td>
<td>4.18</td>
</tr>
<tr>
<td>Nr. of tasks/total nr. tasks</td>
<td>0.48</td>
<td>0.48</td>
<td>0.14</td>
</tr>
<tr>
<td>Revenues</td>
<td>9,420,030</td>
<td>1,186,826</td>
<td>98,268,970</td>
</tr>
</tbody>
</table>
Method of Moments estimation

Estimating $k$ and $\hat{c}$

- Targeted moments: share of offshoring firms $\chi$, first and second moments of $1 - z$
- Method of Moments (minimum-distance) constrained estimation

\[
0 \approx \chi_o - \left\{ \hat{c}^k \left[ 1 - \frac{k}{k+1} \hat{c} \right] \right\},
\]

\[
0 \approx \tilde{c}_o - \left\{ \frac{k}{k+2} \hat{c}^{k+2} + \frac{k}{k+1} - \frac{k}{k+1} \hat{c}^{k+1} \right\},
\]

\[
0 \approx v_o - \left\{ \frac{k}{k+3} \hat{c}^{k+3} + \frac{k}{k+2} - \frac{k}{k+2} \hat{c}^{k+2} - [\hat{c}(k, \hat{c})]^2 \right\}
\]
Method of Moments estimation

Estimating $\sigma$ and $r(1)$

- We use

  \[ \ln r^d(1-z) = \ln r^d(1) + (1-\sigma)\ln(1-z) \]  

- And combine the OLS and FE moment conditions for identification

  \[ \zeta_1 = E \left[ \ln r^d - \ln r_1^d - (1-\sigma)\ln(1-z) \right] = 0, \]
  \[ \zeta_2 = E \left[ \ln r^d - \ln r_1^d - (1-\sigma)\ln(1-z) \right] \ln(1-z) = 0 \]
  \[ \zeta_3 = E \left[ \Delta \ln r^d - (1-\sigma)\Delta \ln(1-z) \right] = 0, \]
  \[ \zeta_4 = E \left[ \Delta \ln r^d - (1-\sigma)\Delta \ln(1-z) \right] \Delta \ln(1-z) = 0 \]
## Results

### Parameter values

<table>
<thead>
<tr>
<th></th>
<th>( \hat{c} )</th>
<th>( k )</th>
<th>( \chi )</th>
<th>( \tilde{c} )</th>
<th>( \text{var}(c) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimates</td>
<td>0.996</td>
<td>1.653</td>
<td>0.377</td>
<td>0.452</td>
<td>0.150</td>
</tr>
<tr>
<td>Targets</td>
<td>0.384</td>
<td></td>
<td>0.555</td>
<td></td>
<td>0.016</td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td></td>
<td>0.007</td>
<td>0.103</td>
<td>0.134</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( \sigma )</th>
<th>( r^d(1) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimates</td>
<td>1.857</td>
</tr>
</tbody>
</table>

*Recovered parameters: \( \kappa \), \( f \), \( f_E \) and \( \tau L/L^* \)*

<table>
<thead>
<tr>
<th>( \kappa )</th>
<th>( f )</th>
<th>( f_e )</th>
<th>( \tau L/L^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>0.115</td>
<td>5,704.08</td>
<td>3,265,730</td>
</tr>
</tbody>
</table>
Results

Welfare effects

- We use the parameter estimates to evaluate the welfare effects of offshoring.

- Using per-capita income as a welfare measure, we compute:

$$\Delta W = 100 \left\{ \left( 1 + \frac{\kappa L^*}{\tau L} \right)^{\frac{1}{\sigma-1}} \left[ 1 - \hat{\epsilon}^k \left( \frac{\sigma-1}{k-\sigma+1} - \hat{\epsilon} \frac{\sigma-2}{k-\sigma+2} \right) \frac{f}{f_e} \right]^{\frac{1}{1-\sigma}} - 1 \right\}$$

- Welfare increases by 192.29 percent when moving from autarky to today.

- In a model variant without overlap, welfare increases by 77.95 percent.
Counterfactual analysis
Changes in the offshoring fixed cost $f$

We evaluate:

- The welfare effects
  - Along the intensive margin of offshoring (i.e. keeping the share of offshoring firms $\chi$ constant)
  - Along the extensive margin of offshoring (i.e. keeping the effective wage differential $\kappa$ constant)

- Effect on the overlap between offshoring and non-offshoring firms
  - Our aggregate measure of overlap is given by

$$
O = \frac{1}{F_c(\hat{c})} \int_{0}^{\hat{c}} \left(1 - \left|1 - 2 \frac{kC^k}{f_c(c)}\right|\right) f_c(c) dc
$$

(3)
Counterfactual analysis

Changes in the offshoring fixed cost $f$
### Model fit

<table>
<thead>
<tr>
<th>Decile</th>
<th>Overlap observed</th>
<th>Overlap computed</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.407</td>
<td>0.002</td>
<td>0.405</td>
</tr>
<tr>
<td>2</td>
<td>0.49</td>
<td>0.012</td>
<td>0.478</td>
</tr>
<tr>
<td>3</td>
<td>0.704</td>
<td>0.037</td>
<td>0.667</td>
</tr>
<tr>
<td>4</td>
<td>0.907</td>
<td>0.103</td>
<td>0.804</td>
</tr>
<tr>
<td>5</td>
<td>0.868</td>
<td>0.276</td>
<td>0.592</td>
</tr>
<tr>
<td>6</td>
<td>0.774</td>
<td>0.744</td>
<td>0.031</td>
</tr>
<tr>
<td>7</td>
<td>0.442</td>
<td>0.495</td>
<td>-0.053</td>
</tr>
<tr>
<td>8</td>
<td>0.466</td>
<td>0.11</td>
<td>0.355</td>
</tr>
<tr>
<td>9</td>
<td>0.452</td>
<td>0.026</td>
<td>0.426</td>
</tr>
<tr>
<td>Average</td>
<td>0.612</td>
<td>0.201</td>
<td>0.412</td>
</tr>
</tbody>
</table>
Robustness checks

**Table: Alternative estimation of $\sigma$**

<table>
<thead>
<tr>
<th>Estimated Model:</th>
<th>$\ln r^d(1 - z) = \ln r^d(1) + (1 - \sigma) \ln(1 - z)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimator</td>
<td>OLS</td>
</tr>
<tr>
<td>$\ln c = \ln(1 - z)$</td>
<td>$-3.022^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.077)</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>$4.022^{***}$</td>
</tr>
<tr>
<td>$r(1)$</td>
<td>88,198</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.503</td>
</tr>
</tbody>
</table>
A model variant without overlap

- No overlap $\rightarrow$ all firms investing $f$ actually start offshoring
- We estimate another set of model parameters based on this new assumption
- We compare the welfare effects of offshoring in the two model variants

Using per-capita income as a welfare measure, we find:
- Welfare increases by 192.29 percent in the model variant with overlap
- Welfare increases by 77.95 percent in the model variant without overlap
## Results - No overlap

<table>
<thead>
<tr>
<th></th>
<th>( \hat{c} )</th>
<th>( k )</th>
<th>( \chi )</th>
<th>( \tilde{c} )</th>
<th>var(( c ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimates</td>
<td>0.529</td>
<td>1.525</td>
<td>0.307</td>
<td>0.555</td>
<td>0.154</td>
</tr>
<tr>
<td>Targets</td>
<td>0.384</td>
<td>0.555</td>
<td>0.016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>−0.005</td>
<td>−0.072</td>
<td>−0.138</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( \sigma )</th>
<th>( r^d(1) )</th>
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**Recovered parameters: \( \kappa \), \( f \), \( f_E \) and \( \tau L/L^* \)**

<table>
<thead>
<tr>
<th>( \kappa )</th>
<th>( f )</th>
<th>( f_e )</th>
<th>( \tau L/L^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>0.247</td>
<td>1,229,820</td>
<td>2,345,320</td>
</tr>
</tbody>
</table>
Conclusions

Summary:

- Tractable model which matches the overlap between offshoring and non-offshoring firms
- Model-based estimation using German firm-level data
- Evaluation of the welfare effects and counterfactual analysis

Main findings:

- Offshoring exerts a welfare stimulus
- Taking into account the overlap magnifies the welfare effects of offshoring

In progress:

- More flexible structure for the correlation between number of tasks and the share of offshorable tasks