Key sectors for economic development: A perspective from inter-sectoral linkages and cross-sector misallocation

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The views I will express next do not necessarily represent the views of Banco de México.
Outline

1. Intro
2. Relevant facts
   - Facts
3. Model
4. Calibration
5. Results
   - Results
6. Conclusion

Julio Leal (Banco de México)
Motivation

- Which are the key sectors for economic development?
  - agriculture, manufacturing, or services?

- What is the role of sector-specific distortions that produce cross-sector misallocation?
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  - agriculture, manufacturing, or services?
- What is the role of sector-specific distortions that produce cross-sector misallocation?
The productivity of highly *interconnected* sectors is an important determinant for aggregate productivity.

Example: Productivity of refined petroleum affects gasoline production, which in turn affects transportation, which affects trade, which affects refined petroleum products, and so on.

It matters:

- The productivity gap of a single sector with respect to the leader.
- The degree of interconnections of this sector with the rest of the economy.

**Definition**

A key sector is one with a large productivity gap and a high degree of interconnections.
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- Sector-specific distortions affect aggregate productivity.
  - Create cross-sector misallocation.
  - Reduce the resources available for consumption.

- The effect of these distortions is also determined by the degree of inter-sectoral linkages.
  - Distortions in highly interconnected sectors have a larger impact on aggregate productivity, than distortions in other sectors.
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What I do

- Set-up a multi-sector model.
  - Output of a given sector can be used as an intermediate input for production in other sectors.
  - Introduces a link between the performance of a single sector, and the performance of the rest.

- Use the model to study three types of distortions per sector:
  - Productivity wedge.
  - Wedge between marginal revenue and marginal cost (a markup).
  - Wedge between the marginal productivity of labor and the marginal cost of labor (MC of labor wedge).

- Calibrate the model for both, the US and Mexico:
  - Make use of input-output tables.
  - Measure the size of distortions in Mexico relative to the US.

- Solve for the equilibrium allocation and perform counter-factual exercises.
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Network map
Share of value added in gross output
Labor income share in GDP, by sector.

Figure: Labor income share in value-added

Supply of labor $H$ is exogenous.

Each sector uses labor, and commodities from all sectors (including its own) to produce.

There exist three wedges per sector in the economy:

- Productivity wedge.
- Markup wedge.
- MC of labor wedge.
Production function of a representative firm in sector $i$:

$$Q_i = A_i (H_i)^{\alpha_i (1 - \sigma_i)} \prod_{j=1}^{N} x_{ij}^{\sigma_{ij}},$$  \hfill (1)

where $\sigma_i = \sum_{j=1}^{N} \sigma_{ij}$; and $\sigma_i + (1 - \sigma_i) \alpha_i < 1$.

Resource constraint of each sector $j$:

$$Q_j = c_j + \sum_{i=1}^{N} x_{ij}, \forall j = 1, \ldots, N.$$

Final good:

$$Y = c_1^{\beta_1} c_2^{\beta_2} \ldots c_N^{\beta_N}.$$
Problem of the final good producer

The problem consists on choosing \( \{c_i\} \), taking \( \{p_i\} \) as given, to solve:

\[
\max \left\{ c_1^\beta_1 c_2^\beta_2 \ldots c_N^\beta_N - \sum_{i=1}^{N} p_i c_i \right\}.
\]

The first order conditions are given by:

\[
\beta_i (Y/c_i) - p_i = 0 \iff \beta_i Y = p_i c_i, \ \forall i.
\]

\[
\beta_i = \frac{p_i c_i}{Y}
\]
The problem of the representative firm in industry $i$ is given by

$$\max_{H_i, \{x_{ij}\}} \left\{ \frac{1}{\psi_i} p_i A_i(H_i)^{\alpha_i(1-\sigma_i)} \prod_{j=1}^{N} x_{ij}^{\sigma_i} - \phi_i w H_i \ldots \right. \right. - \sum_{j=1}^{N} p_j x_{ij} \left. \right\}$$
\[
\frac{1}{\psi_i} \alpha_i (1 - \sigma_i) \frac{p_i Q_i}{H_i} = \phi_i w, \quad \forall i
\]  \hspace{1cm} (3)

\[
\frac{1}{\psi_i} \sigma_{ij} \frac{p_i Q_i}{x_{ij}} = p_j, \quad \forall i, j
\]  \hspace{1cm} (4)
\[
\frac{1}{\psi_i} \alpha_i (1 - \sigma_i) \frac{p_i Q_i}{H_i} = \phi_i w, \quad \forall i
\] (5)

\[
\frac{1}{\psi_i} \sigma_{ij} \frac{p_i Q_i}{x_{ij}} = p_j, \quad \forall i, j
\] (6)
Equilibrium aggregate output

- Equilibrium aggregate output is given by:

\[ Y = \mathcal{A} H^{\tilde{\alpha}} \]

where \( \tilde{\alpha} \) and \( \mathcal{A} \) are constants. Additionally,

\[ \ln(\mathcal{A}) = m' a + \text{const} \]

where:

\[
m' a = [m_1 \ m_2 \ m_3 \ldots m_N] \begin{bmatrix}
\ln A_1 \\
\ln A_2 \\
\ln A_3 \\
\vdots \\
\ln A_N
\end{bmatrix}
\]
Vector of influence:

\[ m' = \beta'(I - B)^{-1} \]

- Two terms:
  - Weights: \( \beta \)
  - Inter-sectoral linkages: \( (I - B)^{-1} \).
    - where typical element of \( B \) is \( \sigma_{ij} \).
- Interpretation: a 1% increase in \( A_i \) rises aggregate GDP in \( m_i \)%.

\[ d\ln(Y) = m_i da_i \]
Allocation of labor

Economy without distortions:

\[
\frac{\hat{H}_i}{H} = \hat{\theta}_i = \frac{\alpha_i(1 - \sigma_i)m_i}{\sum_{s=1}^{N} \alpha_s(1 - \sigma_s)m_s}
\]

- Does not depend on relative productivity \((A_i)\).

Economy with distortions.

\[
\frac{H_i}{H} = \theta_i = \frac{\alpha_i(1 - \sigma_i) \left( \frac{1}{\psi_i} \right) \left( \frac{1}{\phi_i} \right) \tilde{m}_i}{\sum_{s=1}^{N} \alpha_s(1 - \sigma_s) \left( \frac{1}{\psi_s} \right) \left( \frac{1}{\phi_s} \right) \tilde{m}_s}
\]

- where, \(\tilde{m} = \beta'(I - \tilde{B})^{-1}\), and a typical element of NxN matrix \(\tilde{B}\) is \(\sigma_{ij}/\psi_i\).

- If distortions are homogeneous, the allocation of labor is not affected (dispersion is key).
Allocation of labor

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Economy with distortions.

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- where, \( \tilde{m} = \beta' (I - \tilde{B})^{-1} \), and a typical element of \( N \times N \) matrix \( \tilde{B} \) is \( \sigma_{ij}/\psi_i \).
- If distortions are homogeneous, the allocation of labor is not affected (dispersion is key).
Rents of distortions are lost $T = 0$

- In this case distortions are isomorphic to productivity.

\[
\frac{1}{\psi_i} Q_i = \frac{1}{\psi_i} A_i f(H_i, \{x_{ij}\}) = c_j + \sum_{i=1}^{N} x_{ij}, \forall i \tag{7}
\]

- Effect on aggregate output and productivity could be sizable if resources are not given back.
Removal of a single distortion: Total effect

Change in one of the distortions: $\psi_i^1 < \psi_i^0$:

$$\ln \left( \frac{Y^1}{Y^0} \right) = \sum_{j=1}^{N} m_j \alpha_i (1 - \sigma_i) \ln \left( \frac{\theta_j^1}{\theta_j^0} \right) + m_i \sigma_i \ln \left( \frac{\psi_i^0}{\psi_i^1} \right) + \sum_{j=1}^{N} m_j (1 - \sigma_j) \ln \left( \frac{\tilde{m}_j^0}{\tilde{m}_j^1} \right)$$

(8)

1. **Effect on the allocation of labor.**
   - It could be positive or negative depending on whether the change in $\psi_i$ reduces the dispersion of wedges.
   - It depends on the degree of influence of each sector $m_i$.

2. **Effect on aggregate output through the supply of sector $i$ (positive).**

3. **Effect on the allocation of gross output into final and intermediate uses (negative).**
Calibrate the model to Mexico and the US.  
Use the FOC in each country and data from input-output tables to pin-down the value of the parameters.  
Assume that the US is a relatively undistorted economy.  

- Common parameters across countries:
  - $(1 - \sigma_i) =$ VA share in the US.  
  - $\alpha_i =$ Labor share in the US.  
- Use deviations from the 45 degree lines to pin-down $\psi_i$ and $\phi_i$.  

**Figure:** Productivity vs. degree of influence

- 18 Construction; 30 Business Services; 29 Real Estate; 21 Retail Trade;
Closing productivity gaps

**Figure:** Effect in Y of closing the productivity gap

![Graph showing productivity gap effects in various sectors.](image)
Figure: Decomposing the effect in Y of closing the productivity gap

$$m^T = [1, \ldots, 1] / N$$
$$m^T = \beta^T$$
$$m^T = \beta^T (I - B)^{-1}$$
Figure: Calibrated markup values
Reducing distortions: $T > 0$

**Figure:** Effect in $Y$ of reducing markups in Case 1

Effect on $Y$ after closing the markup $\psi$
Reducing distortions: $T = 0$

**Figure:** Effect in $Y$ of reducing markups in Case 2

Effect on $Y$ after closing the markup $\psi$: Case 2
I studied a model with inter-sectoral linkages with wedges and calibrated it to match relevant features of the US and México.

I found that the effect of inter-sectoral linkages is important to determine the gains of closing sectoral productivity gaps.

- Closing the gap in services gives the biggest gains.

I also studied the effect of sector-level distortions and found that its effect could be big depending on whether the rents from distortions stay in the economy or not.
Productivity gap is larger in manufacturing

Data from Inklaar and Timmer (2012)
Productivity gap is larger in manufactures

Data from Herrendorf and Valentinyi (2012)

<table>
<thead>
<tr>
<th>Category</th>
<th>Ratio</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate</td>
<td>( \frac{TFP^{US}}{TFP^{LA}} )</td>
<td>2.30</td>
</tr>
<tr>
<td>Services</td>
<td>( \frac{TFP_{s}^{US}}{TFP_{s}^{LA}} )</td>
<td>1.86</td>
</tr>
<tr>
<td>Goods</td>
<td>( \frac{TFP_{g}^{US}}{TFP_{g}^{LA}} )</td>
<td>3.58</td>
</tr>
</tbody>
</table>

**Table:** Labor share in Mexico

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naive</td>
<td>Compensation of employees / GDP</td>
<td>0.28</td>
</tr>
<tr>
<td>Corrected</td>
<td>Compensation of employees/(GDP-Net Mixed Income-Net indirect taxes)</td>
<td>0.42</td>
</tr>
</tbody>
</table>
Related Literature

- Development literature.
  - Barriers to the use of intermediate inputs in Agriculture (Restuccia et. al, 2008).
  - Barriers to international trade that directly affect industries that produce tradables (Herrendorf and Teixeira, 2005).
  - Financial frictions that affect manufactures more than services. (Buera et. al, 2009).
  - Informality leads to resource misallocation (e.g. Prado, 2011, and Moscoso and D’Erasmo, 2012).

- Literature that shows that the productivity gap is larger in manufactures than in services.
  - Inklaar and Timmer (2012)
  - Herrendorf and Valentinyi (2012)
The problem of the representative firm in industry $i$ is given by

$$\max_{H_i, \{x_{ij}\}, M_i} \left\{ \frac{1}{\psi_i} p_i A_i(H_i)^{\alpha_i} (1-\sigma_i - \lambda_i) \prod_{j=1}^{N} \chi_{ij}^{\sigma_{ij}} M_i^{\lambda_i} - \phi_i wH_i \ldots - \sum_{j=1}^{N} p_j x_{ij} - \rho_{M,i} M_i \right\}$$
FOCs

\[
\frac{1}{\psi_i} \alpha_i (1 - \sigma_i - \lambda_i) \frac{p_i Q_i}{H_i} = \phi_i w, \ \forall i
\]  \hspace{1cm} (9)

\[
\frac{1}{\psi_i} \sigma_{ij} \frac{p_i Q_i}{x_{ij}} = p_j, \ \forall i
\]  \hspace{1cm} (10)

\[
\frac{1}{\psi_i} \lambda_i \frac{p_i Q_i}{M_i} = p_{M,i}, \ \forall i
\]  \hspace{1cm} (11)
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\]  \hspace{1cm} (13)

\[
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\]  \hspace{1cm} (14)
\[ \frac{1}{\psi_i} \alpha_i (1 - \sigma_i - \lambda_i) \frac{p_i Q_i}{H_i} = \phi_i w, \forall i \tag{12} \]

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\[ \frac{1}{\psi_i} \lambda_i \frac{p_i Q_i}{M_i} = p_{M,i}, \forall i \tag{14} \]
Household problem

- Problem:
  \[ \max \{ u(C) \} \quad s.t. \quad C = wH + \Pi + T \]
  where \( T = \text{Rents from distortions} \).

- Resource constraint:
  - If rents from distortions are given back, \( T > 0 \):
    \[ Q_j = c_j + \sum_{i=1}^{N} x_{ij} \]
  - If rents from distortions are not given back, and \( T = 0 \):
    \[ \left( \frac{1}{\psi_i} \right) Q_j = c_j + \sum_{i=1}^{N} x_{ij} \]

Given wedges and import prices, a competitive equilibrium consists on quantities \( Y, \{ Q_i, H_i, c_i, x_{ij}, M_i \}_{i=1}^{N} \); and prices \( w \), and \( \{ p_j \}, \forall i, j = 1, \ldots, N \); such that:

1. \( \{ c_i \} \) solves the representative final good producer problem at the equilibrium prices.
2. \( H_i, \{ x_{ij} \} \) and \( M_i \) solve sector’s \( i \) producer problem at the equilibrium prices and taking \( p_{M,i} \) as given.
3. Markets for labor, and goods \( j = 1, \ldots, N \) clear.
Equilibrium Characterization: multipliers vs. weights

Figure: Multipliers vs. weights
Assume: $t_i = 0$ and $\psi_i = \phi_i = 1$. Then:

$$
\sigma_{ij} = \frac{p_j x_{ij}}{p_i Q_i}.
$$

$$
\implies \sigma_i = \sum_{j=1}^{N} \sigma_{ij} = \sum_{j=1}^{N} \left( \frac{p_j x_{ij}}{p_i Q_i} \right) = \left( \frac{1}{p_i Q_i} \right) \sum_{j=1}^{N} p_j x_{ij}.
$$

is the share of domestic intermediate inputs in gross output.

Similarly:

$$
\sigma_i + \lambda_i = \left( \frac{\sum_{j=1}^{N} p_j x_{ij}}{p_i Q_i} \right) + \frac{p_{M,i} M_i}{p_i Q_i};
$$

(15)

is the share of domestic and imported intermediate inputs in gross output.
Equilibrium Characterization

- Assume: $\tau_i = 0$ and $\psi_i = \phi_i = 1$. Then:

$$\sigma_{ij} = \frac{p_j x_{ij}}{p_i Q_i}.$$  

$$\implies \sigma_i = \sum_{j=1}^{N} \sigma_{ij} = \sum_{j=1}^{N} \left( \frac{p_j x_{ij}}{p_i Q_i} \right) = \left( \frac{1}{p_i Q_i} \right) \sum_{j=1}^{N} p_j x_{ij}.$$  

is the share of domestic intermediate inputs in gross output.

- Similarly, when $\psi_i \neq 1$:

$$\left( \frac{1}{\psi_i} \right) (\sigma_i + \lambda_i) = \left( \frac{\sum_{j=1}^{N} p_j x_{ij}}{p_i Q_i} \right) + \frac{p_{M,i} M_i}{p_i Q_i};$$  

(16)

is the share of domestic and imported intermediate inputs in gross output.
Given parameters in the US, I can compute distortions using Mexico’s FOC:

I match the value added shares in Mexico

\[ \psi_i = \frac{\sigma_i}{\left( \frac{\sum_{j=1}^{N} p_j x_{ij}}{p_i Q_i} \right)^{\text{MX}}} = \frac{\left( \frac{\sum_{j=1}^{N} p_j x_{ij}}{p_i Q_i} \right)^{\text{US}}}{\left( \frac{\sum_{j=1}^{N} p_j x_{ij}}{p_i Q_i} \right)^{\text{MX}}}, \quad \forall i. \]
Calibrated distortions

Figure: Distortions
Problem: we don’t have import prices, we can not calculate productivity levels.

It can be shown that in equilibrium:

\[ \ln \left( \frac{Q_{i}^{mx}}{Q_{i}^{us}} \right) \propto \ln \left( \frac{A_{i}^{mx}}{A_{i}^{us}} \right), \] (17)

Since, I observe \((Q_{i}^{mx}/Q_{i}^{us})\) there is no need to calibrate productivity levels.
Given parameters in the US, I can compute distortions using Mexico’s FOC:

- I match the value added shares in Mexico

\[
\psi_i = \frac{\sigma_i + \lambda_i}{\left( \sum_{j=1}^{N} \frac{p_j x_{ij}}{p_i Q_i} \right)^{MX}} + \left( \frac{p_i Q_i}{p_{M,i} M_i} \right)^{MX}, \quad \forall i.
\]
Calibrated distortions

Figure: Distortions
Key sectors (naive definition)

Figure: Key Sectors
Counter-factual exercises

- Modify the productivity gap in sector $i$, and compute the change in aggregate output $Y$:

\[
\ln \left( \frac{Y^1}{Y^0} \right) \approx \ln \left( \frac{A^1_i}{A^0_i} \right).
\]  

(18)

- Additionally, it can be shown that in equilibrium:

\[
\ln(\frac{Y^1}{Y^0}) = f(\psi^0_i, \psi^1_i),
\]  

(19)

\[
\ln(\frac{Y^1}{Y^0}) = f(\phi^0_i, \phi^1_i).
\]  

(20)
Closing productivity gaps

**Figure:** Change in $A_i$ needed to close the labor productivity gap.

- **Two typical industries**
  - rubber and plastics (manufactures)
  - wholesale and retail trade (services)

- **Productivity**
Reducing distortions

Figure: Reducing distortions

- Two didactic cases
  - post and telecommunications
  - wholesale and retail trade (services)

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Key sectors, linkages, and misallocation ABCDE Conference, 2015 48 / 50
\[ \min \{ wl + rk \} \]
\[ \text{st} \]
\[ Q = f(k, l) \]

FOC

\[ L = wl + rk + \lambda (Q - f(k, l)) \]
\[ \text{FOC:} \]
\[ l : w - \lambda f_l = 0 \]
\[ k : r - \lambda f_k = 0 \]

Reescribir Ec. 1
\[ w - \lambda f_l = 0 \]
\[ w = \lambda f_l Q / Q \]
Conceptual framework

Instituciones
- Banco de México
- SHCP
- SCJN
- Condusef

Políticas
- Impuestos
- Transf. Sociales
- Salud
- Combate al narcotráfico

Incentivos

Informalidad

PIB y Bienestar

Capital Trabajo Productividad

Asignación de Recursos
- Sectores
- Empresas
- Factores
- Ocupaciones

¿?