Technological Differences in Costa Rica

Carlos Chaverri & Alberto Vindas

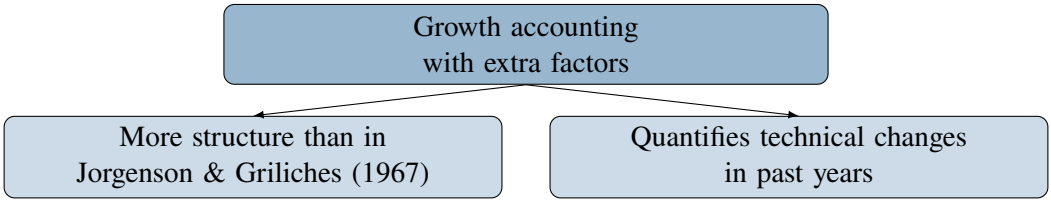
BANCO CENTRAL DE COSTA RICA

Sixth World KLEMS Conference
March 9, 2021

The views expressed herein are those of the authors and not necessarily those of the Central Bank of Costa Rica

In this project we estimate technological differences

- Use a production model that considers:
  - Different economic activities
  - Different types of workers
  - Different types of capital



- In this context:

  Unequal technical change
  =
  technical bias

- Key variation:

  Changes in payments
  vs.
  changes in inputs

We estimate a value added production function

- We follow Caselli (2005), Caselli (2017), Herrendorf, Herrington & Valentinyi (2015)
- Value added is produced according to:

$$P_{i,t}Y_{i,t} = P_{i,t}\left[(A_{\tilde{K},i,t}\tilde{K}_{i,t})^{\rho} + (A_{\tilde{L},i,t}\tilde{L}_{i,t})^{\rho}\right]^{1/\rho}$$

where

- $P_{i,t}Y_{i,t}$ is the nominal value added in activity i
- $\tilde{K}_{i,t}$ and $\tilde{L}_{i,t}$ are *composite* levels of capital and labor
- $A_{\tilde{K},i,t}$ and $A_{\tilde{L},i,t}$ are the productivities associated to these inputs
  - **Do change** among economic activities
- $1/(1-\rho)$ is the elasticity of substitution between capital and labor
  - **Does not change** among economic activities

Composite capital and labor are also CES

- There are M types of capital (denoted by m) and N types of labor (denoted by n):

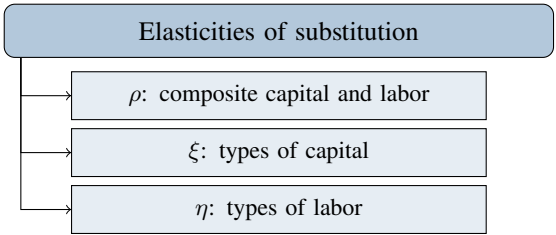
$$\tilde{K}_{i,t} = \left[\sum_{m=1}^{M} \left(A_{K,m,t} K_{i,m,t} \right)^{\xi} \right]^{1/\xi} \qquad \tilde{L}_{i,t} = \left[\sum_{n=1}^{N} \left(A_{L,n,t} L_{i,n,t} \right)^{\eta} \right]^{1/\eta}$$

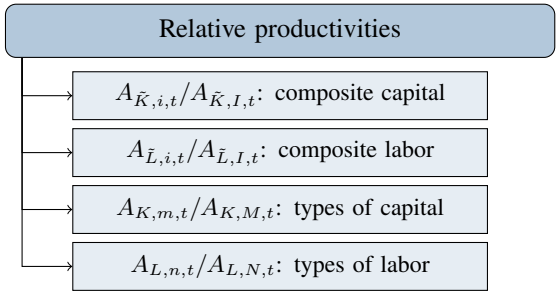
in activity i,

- $K_{i,m,t}$ is the amount of m-type capital
- $A_{K,m,t}$ is its productivity
  - **Does not change** among economic activities
- $1/(1-\xi)$ is the elasticity of substitution among types of capital
  - **Does not change** among economic activities

- $L_{i,n,t}$ is the amount of n-type labor
- $A_{L,n,t}$ is its productivity
  - **Does not change** among economic activities
- $1/(1-\eta)$ is the elasticity of substitution among types of labor
  - **Does not change** among economic activities

Estimation results





- Results so far reveal that:
  - Capital and labor substitute with relative ease
  - Types of capital are complements
  - Types of labor are strong complements
  - Some patterns are not reasonable, and need further study

OLS on optimality conditions allows estimation of most parameters

$$\ln\left(\frac{W_{i,n,t}L_{i,n,t}}{P_{i,t}Y_{i,t}}\right) = \sum_{t=1}^{T}\sum_{i=1}^{I}\gamma_{i,t}^{L}\mathbb{I}(i,t) + \sum_{t=1}^{T}\sum_{n\neq N}\gamma_{n,t}^{L}\mathbb{I}(n,t) + \zeta_n \ln\left(L_{i,n,t}\right) + \varepsilon_{i,n,t}$$

- In this context:
  - $\gamma_{i,t}^{L} = \rho \log\left(A_{\tilde{L},i,t}\right) + (\rho - \eta)\log\left(\tilde{L}_{i,t}\right) + \eta \log\left(A_{L,N,t}\right) - \rho \log\left(Y_{i,t}\right)$
  - $\gamma_{j,t}^{L} = \eta\left(\log\left(A_{L,j,t}\right) - \log\left(A_{L,N,t}\right)\right)$
  - $\zeta_n = \eta$
- Results:
  - $A_{L,j,t}/A_{L,J,t}$
  - $A_{\tilde{L},i,t}A_{L,J,t}$
  - η

OLS on optimality conditions allows estimation of most parameters

$$\ln\left(\frac{R_{i,m,t}K_{i,m,t}}{P_{i,t}Y_{i,t}}\right) = \sum_{t=1}^{T}\sum_{i=1}^{I}\gamma_{i,t}^{K}\mathbb{I}(i,t) + \sum_{t=1}^{T}\sum_{m\neq M}\gamma_{m,t}^{K}\mathbb{I}(m,t) + \zeta_K \ln\left(K_{i,m,t}\right) + \varepsilon_{i,m,t}$$

- In this context:
  - $\gamma_{i,t}^{K} = \rho \ln\left(A_{\tilde{K},i,t}\right) + (\rho - \xi)\ln\left(\tilde{K}_{i,t}\right) - \rho \ln\left(Y_{i,t}\right) + \xi \ln\left(A_{K,M,t}\right)$
  - $\gamma_{m,t}^{K} = \xi \ln\left(A_{K,m,t}\right) - \xi \ln\left(A_{K,M,t}\right)$
  - $\zeta_m = \xi$
- Results:
  - $A_{K,m,t}/A_{K,M,t}$
  - $A_{\tilde{K},i,t}A_{K,M,t}$
  - ξ

Capital and labor substitute with relative ease

- By normalizing manufacturing's productivity, we get $\rho = -0,106$
  - The elasticity of substitutions is 0,904, in line with some of the findings in Caselli (2005)

- The optimality conditions between capital and labor imply:

$$\frac{\tilde{W}_{i,t}}{\tilde{R}_{i,t}} = \left(\frac{A_{\tilde{L},i,t}}{A_{\tilde{K},i,t}}\right)^{\rho} \left(\frac{\tilde{K}_{i,t}}{\tilde{L}_{i,t}}\right)^{1-\rho}$$

- When prices change, $1 - \rho$ determines changes in relative demands
- If $\rho = -0,106$, it's close to a Cobb-Douglas production function
  - Increases in prices cause reductions in relative demand, but less than proportionally

Types of capital and types of labor are complements among themselves

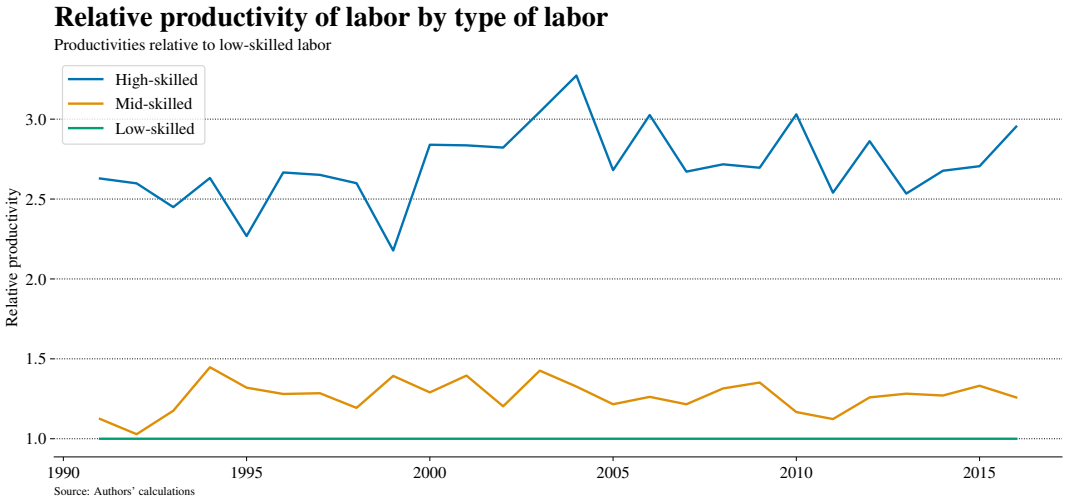
Types of capital

- Estimation yields $\hat{\xi} = 1,1878$
- Elasticity of substitution is lower
  - Point estimate is -5,32
- Complementarity among types of capital is strong

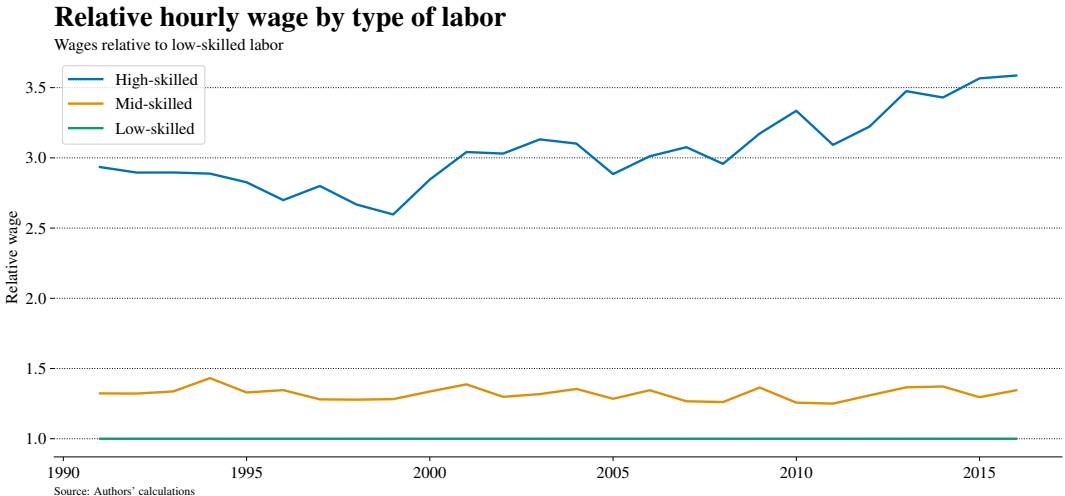
Types of labor

- Estimation yields $\hat{\eta} = 1,0243$
- Elasticity of substitution is much lower
  - Point estimate is -41,15
- Complementarity among types of labor is very strong!

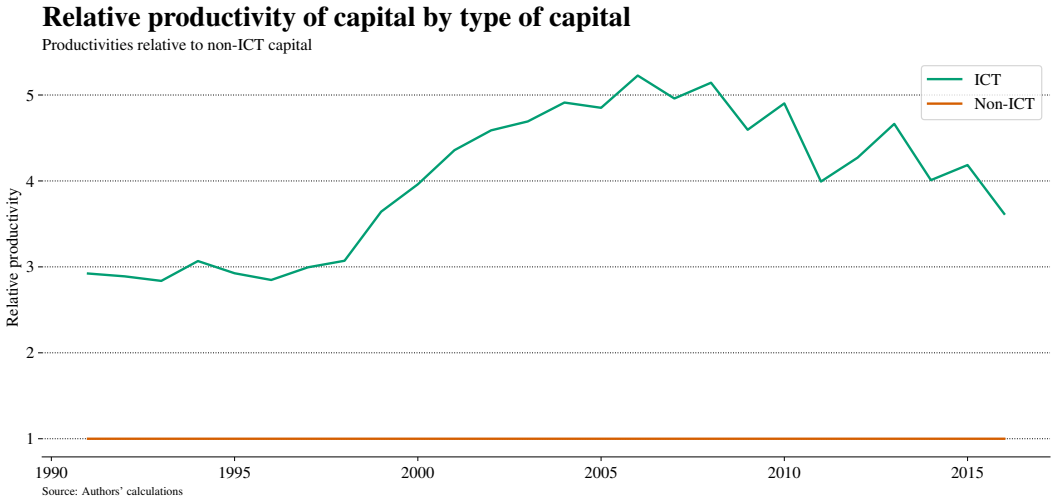
Labor productivities explain most of wage gap



Labor productivities explain most of wage gap



ICT capital more productive, gap closes in later years



Results also measure differenes among activities

- We've measured differences in productivities among
  - Types of labor
  - Types of capital
- We can also measure productivity differences among activities
  - Composite labor
  - Composite capital
- Further data work required to obtain reasonable estimates

Results are preliminary, data work pending

- Model allows to:
  - Gain insights on elasticities of substitution
  - Quantify relative productivities
- First attempt in Costa Rica with such level of detail!
- Current challenge: more data work
  - Some productivity estimates are too volatile
  - Looking into sources of unusual patterns
  - Data smoothing may be used

References

Caselli, Francesco. 2005. “Chapter 9 Accounting for Cross-Country Income Differences.” In . Vol. 1 of *Handbook of Economic Growth*, , ed. Philippe Aghion & Steven N. Durlauf, 679 – 741. Elsevier.

Caselli, Francesco. 2017. *Technology Differences over Space and Time.* Princeton University Press.

Herrendorf, Berthold, Christopher Herrington, & Ákos Valentinyi. 2015. “Sectoral Technology and Structural Transformation.” *American Economic Journal: Macroeconomics*, 7(4): 104–33.

Jorgenson, D. W., & Zvi Griliches. 1967. “The Explanation of Productivity Change.” *Review of Economic Studies*, 34(3): 249–283.

Types of capital are complements

- Estimation results for capital payments are:

Dependent variable:	logRKshare	R-squared:	0,984
Method:	OLS	Adjusted R-squared:	0,964
Observations:	468	F-statistic:	49,26
Degs. of freedom:	260	Prob. (F-statistic):	1,18E-119
Log-likelihood:	-77,32	AIC:	676,6

Variable	Coefficient	Std. error	T-Statistic	P>|t|	[0,025,	0,975]
logK (ξ)	1,1878	0,029	41,252	0	1,131	1,245

- Elasticity of substitution is lower
  - Point estimate is -5,32
- Complementarity among types of capital is strong

Types of labor are strong complements

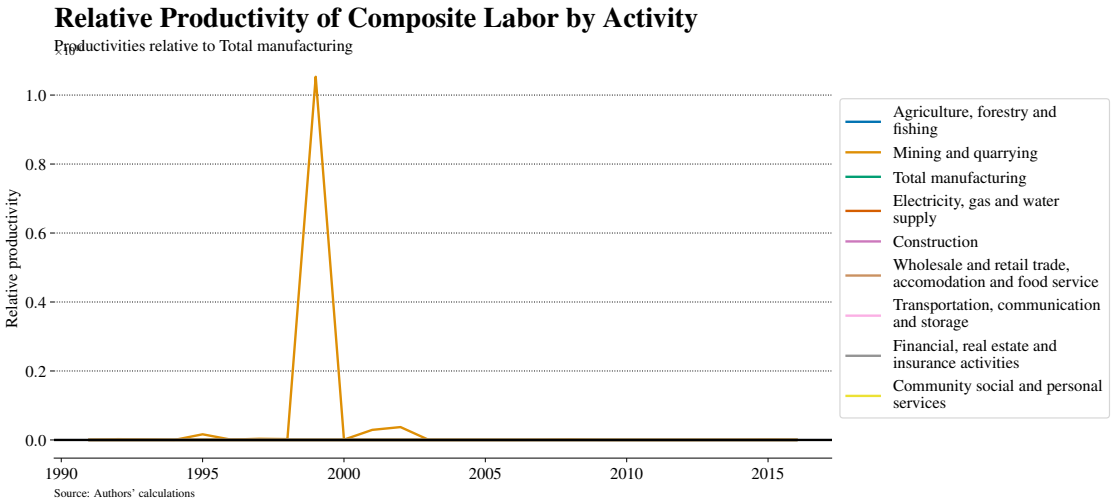
- Estimation results for labor payments are:

Dependent variable:	logWLshare	R-squared:	0,964
Method:	OLS	Adjusted R-squared:	0,939
Observations:	700	F-statistic:	38,36
Degs. of freedom:	286	Prob. (F-statistic):	1,72E-199
Log-likelihood:	322,09	AIC:	-70,19

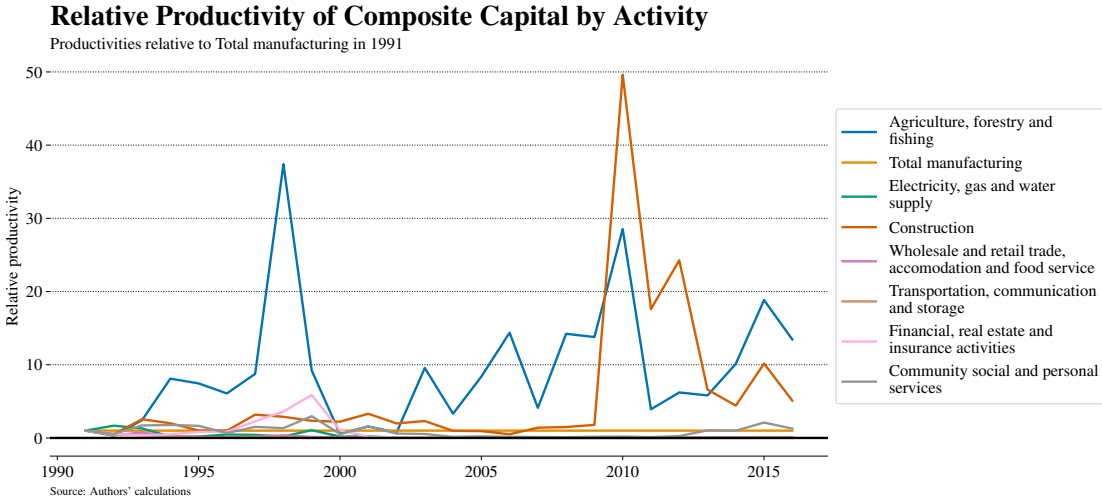
Variable	Coefficient	Std. Error	T-Statistic	P>|t|	[0,025,	0,975]
logL (η)	1,0243	0,014	71,846	0	0,996	1,052

- Elasticity of substitution is much lower
  - Point estimate is -41,15
- Complementarity among types of labor is very strong!

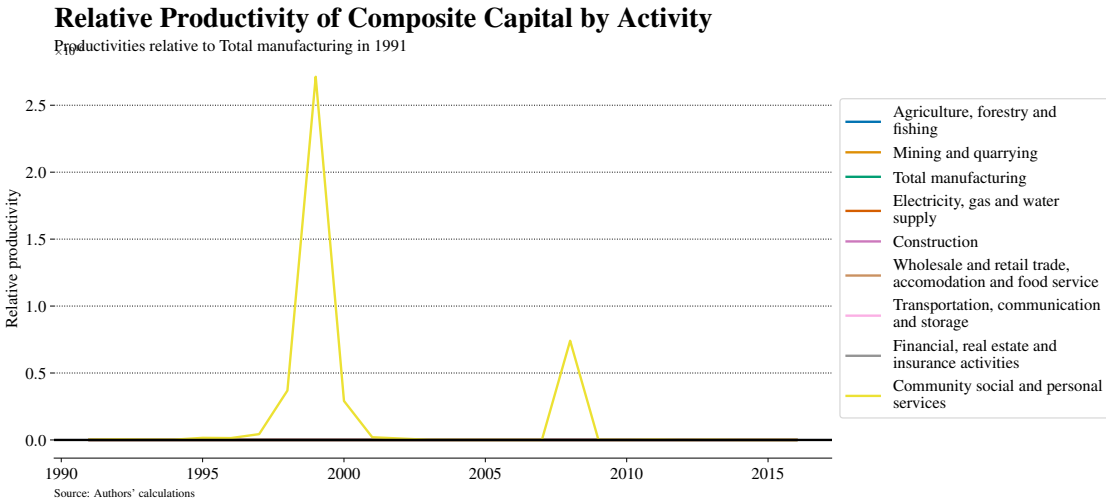
Unlikely results: labor productivity in mining and extraction



Unlikely results: labor productivity in agriculture and construction



Unlikely results: capital productivity in community and personal services



Unlikely results: composite capital productivities