The Effect of Remoteness on Agricultural Productivity: Learning from Peru (Work in Progress)

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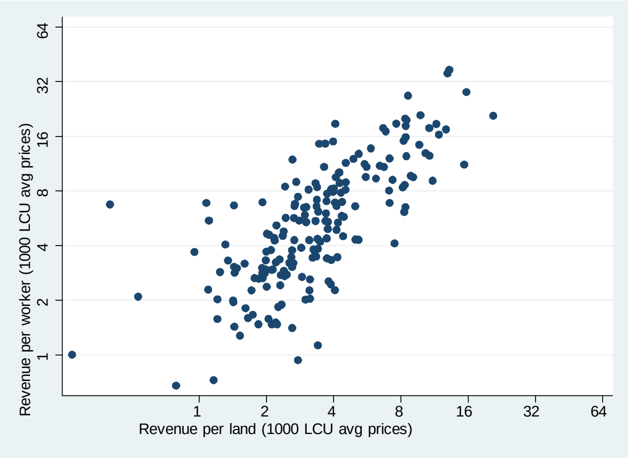
Motivation I

- Agricultural productivity is important to understand why countries are poor
- **Across countries** (Restuccia et al., 2008)**:**
  - Agricultural GDP per capita of richest countries is $\sim$78 times that of poorest countries
  - But overall the factor is only $\sim$30

Motivation II

- **Within Peru:** Revenue per worker in most productive provinces ∼30 times that of least productive provinces



Each dot is a province. Year 2008

What I do

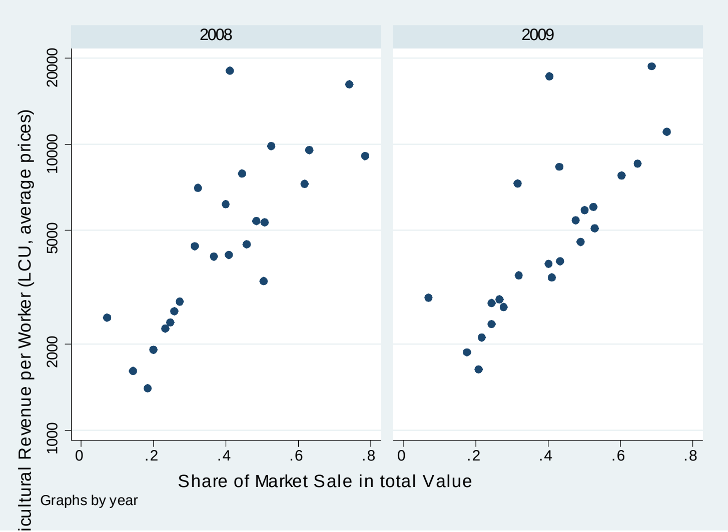
- Propose one explanation:
  - Bad transportation infrastructure and adverse geography ⇒ High transport costs
  - High transport costs affects agriculture more than other sectors because it is tied to land
- Use Peruvian data to quantify it within a Ricardian intranational trade model
  - Geographical dispersion of prices: trade costs
  - Output, land use by crops + Census data: production functions and land productivity

Channels

1. Productivity gains from trade
    1.1 Low price of farmer's output
    1.2 High price of goods produced somewhere else
2. High price of modern inputs
3. Interaction with income and preferences to determine the allocation of productive resources

Reduced form evidence I

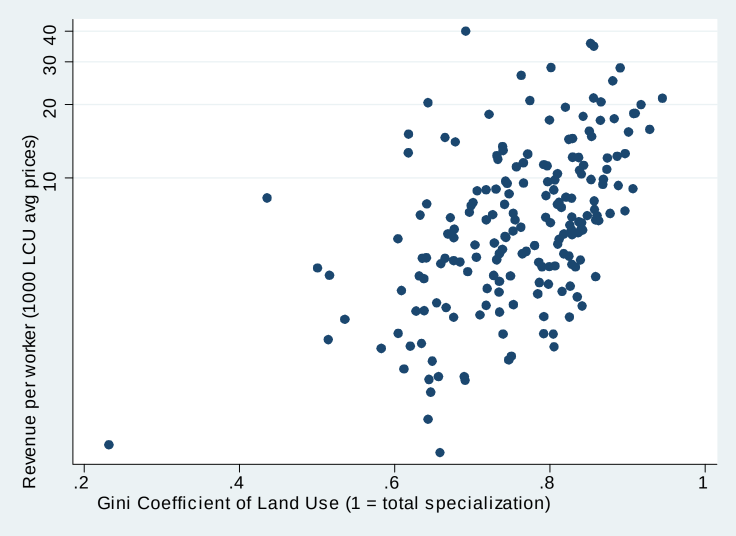
Market access and Revenue per worker



Each observation is a department

Reduced form evidence II

Specialization and Revenue per worker (2008)



Each observation is a province

What I do not do (yet)

- Consider diversification to mitigate risk
- Discuss technology adoption
- A theory of trade costs

Roadmap

1. Literature Review
2. Simple model to explain mechanisms
3. Preliminary Quantification
4. Future work

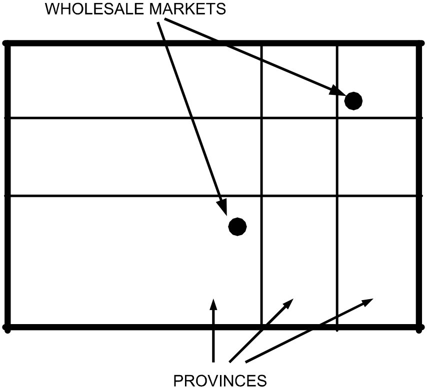
Literature Review

- **Two-sector approaches**: Gollin et al. (2005, 2007), Restuccia et al. (2008), Tombe (2011), Lagakos and Waugh (2012)
- **Agricultural productivity and transportation costs**: Gollin and Rogerson (2010), Adamopoulos (2011)
- **Gains from trade in agriculture and within-country geography**: Donaldson (2010), Allen (2012), Costinot and Donaldson (2012), Costinot et al. (2012)
- **Geography and Development in Peru**: Escobal (1994), Escobal (2001), Escobal and Torero (2003)
- **Quantitative trade models**: EK (2002), Simonovska and Waugh (2011)

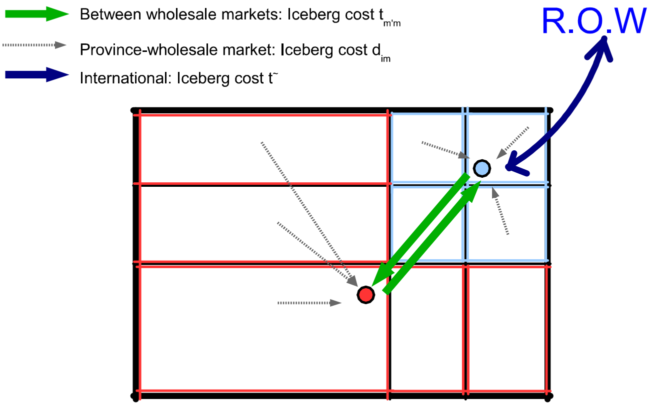
Model

- Structure driven by data availability
- Small open economy
- Agriculture is the only sector, K crops

Geography and Trading possibilities



Geography and Trading possibilities



Wholesale markets

- A set of M wholesale markets, indexed by m
- Each market indexed with a vector of prices $\bar{p}_m$
- Iceberg cost of shipping a good from m to m': $t_{m'm} > 1$

Provinces

- Set of N provinces, indexed by i (provinces)
- Endowments:
  - Labor $\bar{L}_i$
  - Land $\bar{H}_i$
  - Associated productivities $\left\{ A_i^k \right\}$ in each crop
- Iceberg cost of trading with closest wholesale market: $d_{im(i)} > 1$

Representative Households

$$\max_{\substack{C^k, q^k, H^k, L^k \\ E, P, I}} \prod_{k=1}^{K} \left(C^k \right)^{\beta^k}$$

$$s.t$$

- Technology

$$q^k = F^k \left(A^k H^k, L^k \right), \ \forall k \in E, P$$

- Resource constraints

$$\begin{aligned} C^k &\leq q^k, \ \forall k \in E, P \\ \Sigma_k L^k &\leq \bar{L} \\ \Sigma_k H^k &\leq \bar{H} \end{aligned}$$

- Budget constraint

$$\Sigma_{k \in I} d \bar{p}^k C^k = \Sigma_{k \in E} \frac{\bar{p}^k}{d} \left(q^k - C^k \right)$$

Closing the model

- Trade with the rest of the world
- International prices $\tilde{p}$
- International trade costs $\tilde{t}$

Data

1. MINAG - SISAGRI
   - Farm-gate price, output and land use by crop
   - District level
   - Monthly 2008-2012
2. MINAG - SISAP
   - Wholesale prices for 29 cities
   - Monthly, 2001 - 2011
3. INEI - Census 2007
   - Estimates of labor in agriculture
4. ADEX
   - Transaction-level data (customs)
   - Daily 2000 - 2011

Example

- Suppose:
  1. Technology (low EoS)

$$q_i^k = A_i^k \min\left\{ H_i^k, \frac{L_i^k}{b^k} \right\}$$

  2. In equilibrium, labor in short supply $\Rightarrow$ allocated optimally at the margin
  3. Chain of CA

$$\frac{\bar{p}^{k_1} A^{k_1}}{b^{k_1}} > \ldots > \frac{\bar{p}^{k_K} A^{k_K}}{b^{k_K}}$$

Example - Solution

- Export a "cash crop"

$$E = \{k_1\}$$

- Produce for own consumption if cheaper than buying

$$P = \left\{ k : \underbrace{d\bar{p}^k}_{\text{unit cost of buying}} > \underbrace{\frac{1}{A^k / b^k}}_{\text{labor requirement}} \times \underbrace{\frac{\bar{p}^{k_1}}{d} \frac{A^{k_1}}{b^{k_1}}}_{\text{revenue foregone}} \right\}$$

Decomposition of productivity losses

- Evaluate output at some price vector p (as agencies do)

$$
\begin{aligned}
\frac{\pi}{\pi^{frictionless}} = & \underbrace{\left(S_I + S_E\right)}_{\text{No losses}} \\
& + \underbrace{S_P \left[\frac{Avg\left(p\right) Avg\left(A/\,b\right)}{p^{k_1} A^{k_1} /\, b^{k_1}}\right]}_{\text{Produce crops with low productivity}} \\
& + \underbrace{S_P \left[\frac{Cov_P\left(p, A/\,b\right)}{p^{k_1} A^{k_1} /\, b^{k}}\right]}_{\text{Arbitrary covariance between prices and productivity}}
\end{aligned}
$$

where $S_\omega = \sum_{k\in\omega} \beta^k, \omega \in \{E, P, I\}$

Lower bound to productivity losses

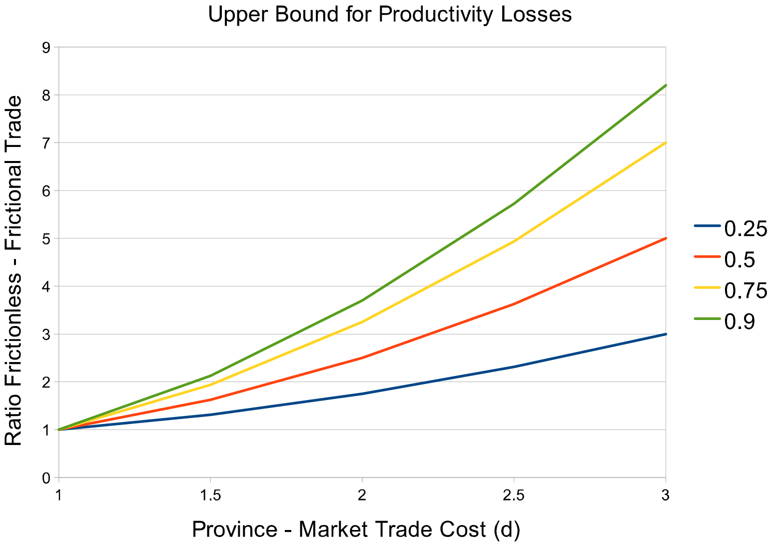
- Value output at wholesale market prices $\bar{p}$
- If all frictions are trade-related:

$$\frac{\pi}{\pi^{frictionless}} \leq (S_I + S_E) + S_P \frac{1}{d^2}$$

where $S_\omega = \sum_{k \in \omega} \beta^k, \omega \in \{E, P, I\}$

- S_I, S_E, S_P are also functions of d
- If d^k is crop-specific may introduce further distortions

Lower bound to productivity losses



Example - Bottomline

- A remote region:
  - Less productive
  - Participates less in the market
  - Specializes less or incorrectly
- Some reduced-form evidence next

Estimation of between-city transport costs

- Suppose we have price data $\rho^k_{m,t}$
- And goods can be classified: $g = g_1, \ldots, g_G$
- Follow EK (2002) and Simonovska and Waugh (2012)
  1. Fix m and m'
  2. For each k, t, compute $\hat{t}^k_{m'm,t} = \rho^k_{m',t} / \rho^k_{m,t}$
  3. Assume no time-specific variation

$$\hat{t}^g_{m'm} = \max_{t,k \in g} \left\{ \hat{t}^k_{m'm,t} \right\}$$

  4. Assume no good-specific variation

$$\hat{t}_{m'm,t} = \max_{k} \left\{ \hat{t}^k_{m'm,t} \right\}$$

Estimation of between-city transport costs

Table 1A. Analysis of Between City Trade Costs

Summary Statistics			
Mean	2.74		
Standard Deviation	1.69		
Observations	6048		

Percentiles	25th	50th	75th
	1.72	2.28	3.16

Estimation of between-city transport costs

Table 1B. Analysis of Between City Trade Costs

$$\log \hat{t}^k_{m'm} = \beta \log\left(\text{distance}_{m'm}\right) + \alpha^k + \alpha_m + \alpha_{m'}$$

Regressions

	(1)	(2)	(3)	(4)	(5)
regressors: ↓					
$\log\left(\text{distance}_{m'm}\right)$	0.056	0.050	0.056	–	0.050
	(.001)	(.001)	(.006)		(.005)
Origin,Destination F.E	No	Yes	No	No	Yes
Product Group F.E	No	No	Yes	Yes	Yes
R^2	0.009	0.27	0.28	0.27	0.54

Estimation of between-city transport costs

- In previous regression (4)

Table 2. Importance of Crop Groups in Trade Costs

Group	α^k
roots and tubers	1.03*** (omitted)
agroindustrial	-0.49***
cereals	-0.16***
fruits	0.28***
meat	-0.45***
legumes	-0.14***
vegetables	-0.17***
other	0.03

Estimation of production functions

- Optimality in production

$$q_i^k = A_i^k H_i^k = A_i^k L_i^k / b^k$$

- Substitute in

$$\sum_k L_i^k = \bar{L}_i$$

- Derive regression equation

$$\sum_k H_i^k b^k = \bar{L}_i,$$

where H_i^k and $\bar{L}_i$ are observable

- Easiest theory of error: Measurement of $\bar{L}_i$
  - Others work, too (parameter heterogeneity, measurement of H_i^k)

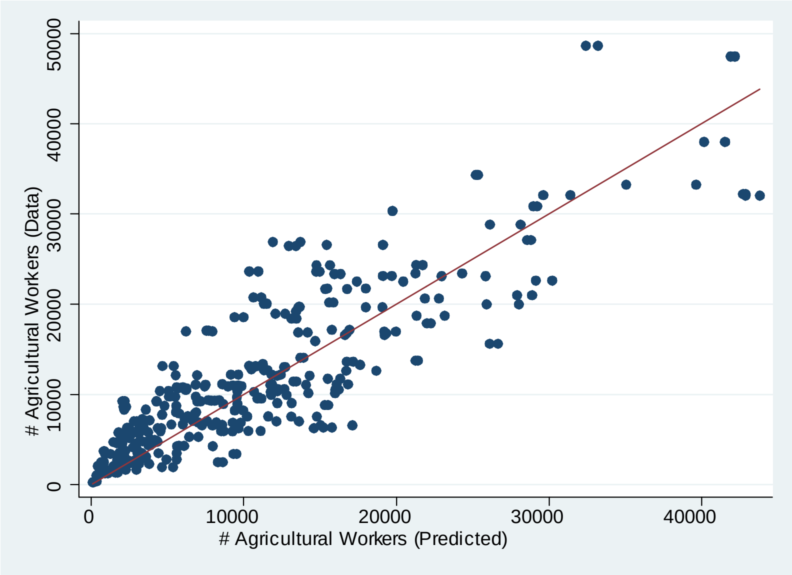
Estimation of production functions (2 classifications)

Crop group	b^k	Cannock & Geng (1994)	b^k
Cereals	0.37***	Onion	$\frac{210}{365} = .58$
Vegetables, Melons	1.50***	Tomatoes	$\frac{120}{365} = .33$
Fruits and nuts	0.92***	Bananas	$\frac{79}{365} = .22$
Oilseed crops	0.26		
Roots and tubers	0.77***	Sweet potatoes	$\frac{56}{365} = .15$
Beverage and spice	0.35***		
Legumes	1.51***		
Sugar crops	-0.05		
Other (inc. Fodder)	0.04		
R^2	0.90		

At the province level. Pooling years 2008-2009

- To compare to Cannock & Geng (1994): $b^k \approx \hat{m}^k/365$, where $\hat{m}$ is their requirement of man-days per ha.

Estimation of production functions (Fit)



Preliminary estimation of local trade costs

Table 3. Analysis of Between City Trade Costs

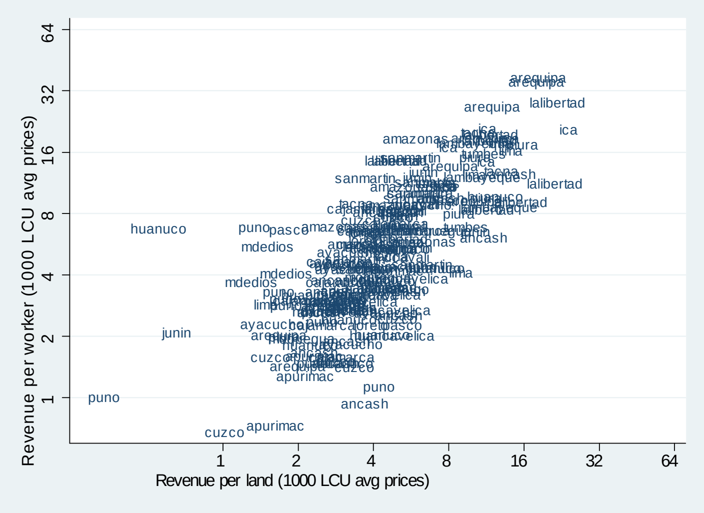
Summary Statistics	
Mean	1.94
Median	1.26
Standard Deviation	1.64
Observations	10,569

Conclusions

- Proposed a reason for low agricultural productivity
- Potentially important
- Preliminaries of quantification
- Still much to be done

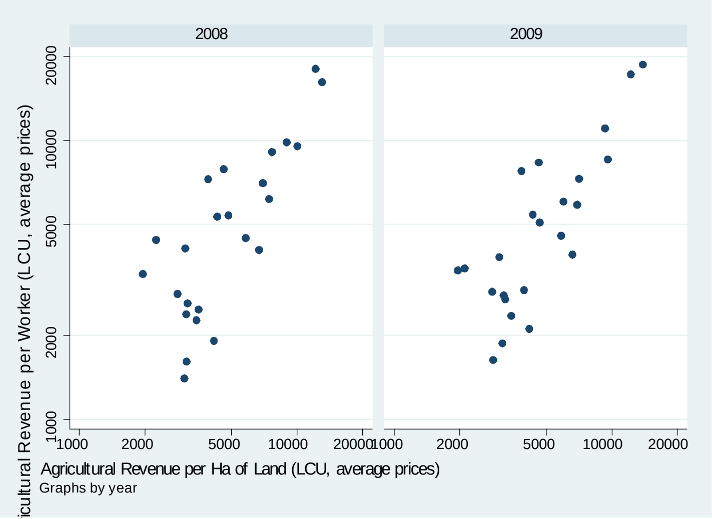
Appendix

Motivation II



Each dot is a province. Year 2008

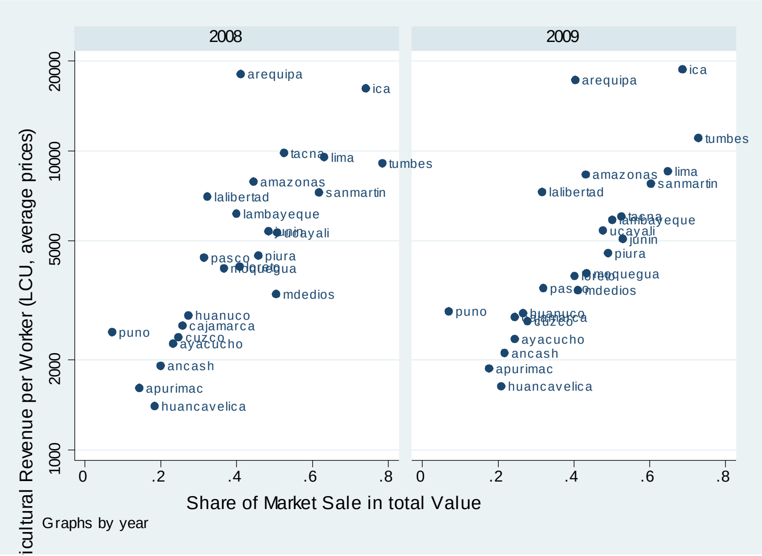
Productivity and Land per Worker



Each dot is a department

Reduced form evidence I

Market access and Revenue per worker



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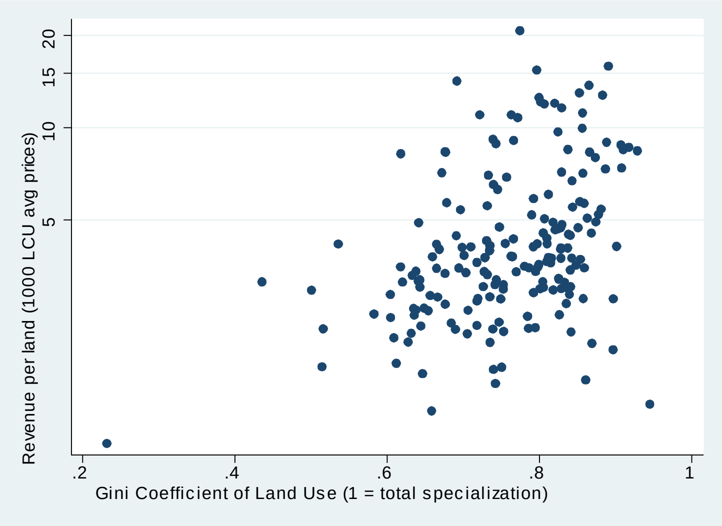
Reduced form evidence II

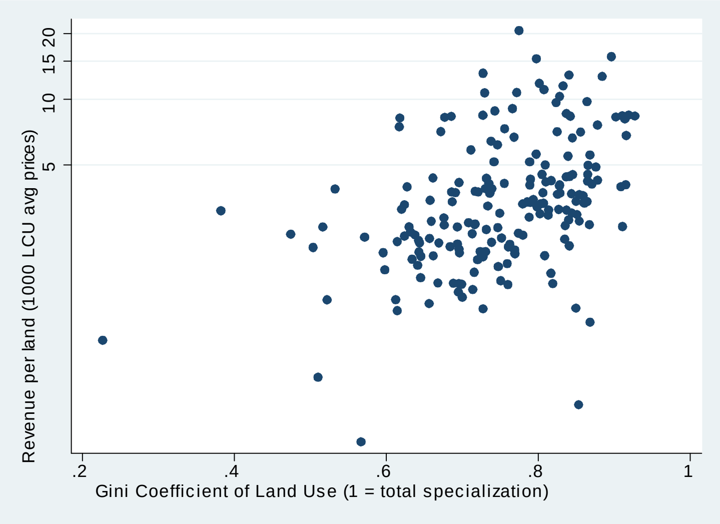
Specialization and Revenue per land (2008)



Including Pasture and Fodder

Reduced form evidence II

Specialization and Revenue per land (2008)



Excluding Pasture and Fodder

Estimation of local trade costs

- A first pass at estimation

$$\hat{d}_{mi} = \frac{\bar{p}_m^k}{p_i^{f,k}}$$

- But biased
  1. If m is sourcing from a third location

$$\bar{p}_m^k < d_{mi} p_i^{f,k} \Rightarrow d_{mi} > \hat{d}_{mi} = \frac{\bar{p}_m^k}{p_i^{f,k}}$$

  2. If m ships to i

$$\bar{p}^k d_{mi} = p_i^{f,k} \Rightarrow \hat{d}_{mi} = \frac{\bar{p}_m^k}{p_i^{f,k}} = (d_{mi})^{-1}$$