Micro Founded Macro Models -

• Theoretical models tell well articulated, plausible stories of the impact of the financial sector on growth, inequality, poverty. But how do we know that these models match up to reality and can thus help us in the formulation of policy?

• This lecture shows how to estimate the key financial economic underpinnings of two well known, pre-existing models in the literature. The case study is Thailand but we extend this local within-country data and to data from other countries.

• We do this by fitting micro economic data to the choices that households and businesses make, thus delivering a subset of the key parameters. The remaining parameters are calibrated at plausible values, but typically using only subsets of the data, as with initial conditions. Then the model at all these imposed parameter values is simulated over time, and predicted paths of macro aggregates are compared to actual time paths in the data. Macro aggregates include growth, inequality, income, savings rates, and labor share of GDP, as well as key parts of each model, that is, the fraction of households running business or the fraction of households participating in the financial sector. Financial deepening is exogenous, imposed at observed values in one model, and endogenous, a key choice in the other.
Micro Founded Macro Models (cont.) -

- Each model lends itself to a quantification of the welfare gains from a policy intervention. In the model with an exogenous expansion of the financial sector, we can measure impact on winners as well as losers, as households may or may not shift occupations as access to credit and savings increases, and even when they do not shift, there are changes in investment on the intensive margin. The impact of financial deepening depends as well on endogenous wages and interest rates; eventually increasing wages have a huge impact on the relatively poor who do not start businesses but work for others. In the model with endogenous financial deepening, a government takeover of the banking system creates an inefficiency wedge which is associated with a clearly evident stagnation in growth rates. The welfare loses from this repression, and conversely the welfare gains from subsequent financial liberalization are quantified using the lens of the model.

- Though welfare gains as a fraction of wealth from financial liberalization can be quite large, the impact on subsequent growth can be small, if not negligible, as growth depends on the endogenous expansion of the financial system, which depends on investment in costly infrastructure. Likewise, time series and panel data generated from the model offer a stark warning that running cross-country regressions to assess the impact of finance on growth and inequality is treacherous if the data come from actual economies in transitions (not yet in steady state).

- The larger theme here, however, is not to promote these two models as the end of the story, but rather to promote the method of analytic attack. The models are relatively successful in Thailand, but fit less well in Mexico, especially during a devaluation and sudden stop. As it turns out, that outcome was predictable from the first step, from the ability the assumed key ingredients to fit the micro data. Indeed, one can take each of the models to local, village and regional data within Thailand, and deduce that the occupation choice model is reasonably successful, but the financial depending model does not take into the account the contrasting behavior of government vs. private sector financial service providers. The lecture ends with a comparison of the successes and failures of each model, hence directions for further research. Ultimately policy recommendations vary from one model to the next so it is important to find one that is approximately correct in both its micro and macro aspects.
“Growth and Inequality: Model Evaluation Based on an Estimation-Calibration Strategy” Jeong & Townsend, 2003 -

Our purpose is to understand growth and inequality. We do this through an evaluation of macro models that are explicit about micro underpinnings and impediments to trade. We use the explicit structure of the macro models to make exact numerical predictions for aggregate dynamics, the dynamics of key groups, and end-of-sample period income distributions, and we compare these predictions to those objects in the data from a given, selected country. In this sense, we take the theory seriously as in the calibration, real business cycle literature. However, the parameters of preferences, technology, and distribution of shocks that we use are neither arbitrarily chosen nor borrowed from other studies. Rather, we explicitly estimate the key parameters using the models’ micro···"
Static Applied General Equilibrium: Dual Sector Model

- Bernhardt and Lloyed-Ellis (Restud 2000) and Gine and Townsend (2004)
  - Occupational choice: Farmers, Workers and Entrepreneurs
  - Given distribution of talent, i.e. fixed-cost of opening a firm $H(x)$ over $(0,1)$, distribution of inherited wealth $G(b)$
  - Farmers: $W = \gamma + b$
  - Workers: $W = w - v + b$
  - Entrepreneurs:
    $W = \max_{0 \leq l \text{ and } 0 \leq k \leq b-x} \{ f(k, l) - wl - (k + x) \} + b$
  - A person with inherited wealth $b$ and talent $x$ chooses her profession to maximize $W$: $w > \underline{w} = v + \gamma$ then no one will be farmer. If $x \leq x^e(b, w)$ then she will become an entrepreneur, otherwise she will become a worker.
Empirical Observations on Mexico and Thailand  Calibration  DSGE with Financial Sector  New models

Static Applied General Equilibrium: Dual Sector Model

- Transition

![Diagram showing occupational choices between subsisters and workers and unconstrained entrepreneurs.]

Fig. 1. Occupational choice map.


- General equilibrium:
  - \( E (w) = \int H(x^e(b, w)) G(db) \) and
  - \( L(w) = \int \int_0^{x^e(b,w)} l(b, x, w) H(dx) G(db) \)
  - \( E(w) + L(w) \leq 1 \) with equality if \( w > w_0 \).
LEB Model

• Model Economy

\[ u(c_t, b_{t+1}) = c_t^{1-\infty} b_{t+1}^{-\infty} \]

There are two kinds of production technologies. In traditional sector, everyone earns a safe subsistence return \( \gamma \) of a single consumption good. In modern sector, entrepreneurs hire capital \( k_t \) and labor \( l_t \) at each date \( t \) to produce the single consumption good according to a production function

\[ f(k_t, l_t) = \alpha k_t - \frac{\beta}{2} k_t^2 + \xi l_t - \frac{\rho}{2} l_t^2 + \sigma l_t k_t. \]

For the rest of the article please visit: "Growth and Inequality: Model Evaluation Based on an Estimation-Calibration Strategy." by Hyeok Jeong and Robert M. Townsend. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2864508/#
Given $W$ each person solves $\max_{C + B \leq W} U(C, B)$ this gives the bequest function $B(W)$.

$G_t(b) \rightarrow w_t \rightarrow G_{t+1}(b)$

The phases of economic development:

- Phase 1 (the Dual Economy, $0 \leq t \leq \tau_1$) Wages remain at $w$. Incomes and wealths grow in the first-order stochastic sense.
- Phase 2 (the Transition, $\tau_1 \leq t \leq \tau_2$) Wages begin to rise, but income and wealths continue to grow in the first-order stochastic sense.
- Phase 3 (Advanced Economic Development, $t \geq \tau_2$) Wages rise, and incomes and wealths grow in the second-order stochastic sense.
- Phase 4 (Long Run) Wages converge and the distribution of incomes and wealths converage to unique limiting distributions which are independent of the initial distribution.
A fraction $\alpha$ of people have access to borrowing and lending, equilibrium interest rate $R$

- Farmers: $W = \gamma + Rb$
- Workers: $W = w - v + Rb$
- Entrepreneurs:
  \[
  W = \max_{0 \leq l \text{ and } 0 \leq k} \{f (k, l) - wl - R (k + x)\} + Rb
  \]
- If $x \leq \tilde{x} (R, w)$ then she will become an entrepreneur, otherwise she will become a worker.

General equilibrium $(w, R)$ are such that

- $S (w, R) = \alpha b$ and
- \[
  D (w, R) = \alpha \int \int_0^{\tilde{x} (R, w)} (k (R, w) + x) H (dx) G_1 (db)
  \]
- \[
  E (w) = \alpha \int H (\tilde{x} (R, w)) G_1 (db) + (1 - \alpha) \int H (x^e (b, w)) G_2 (db)
  \]
  and \[
  L (w) = \alpha \int \int_0^{\tilde{x} (R, w)} I (R, w) H (dx) G_1 (db) +
  \]
  \[
  (1 - \alpha) \int \int_0^{x^e (b, w)} I (b, x, w) H (dx) G_2 (db)
  \]
- $D (w, R) \leq S (w, R)$ with equality if $R > 1$
- $E (w) + L (w) \leq 1$ with equality if $w > \underline{w}$
Empirical Observations on Mexico and Thailand

Calibration

DSGE with Financial Sector

New models

Policy Impact

Gine and Townsend (2004) Thailand

INTERMEDIATION IMPACTS GROWTH, INTERMEDIATION, INEQUALITY, POVERTY, # FIRMS

Macro simulation: Credit Matters

Eventual diminishing Returns, BUT WE GET TFP

Investment will move too

Dynamics due to improved intermediation

$\eta = .026$, $\omega = .321$, $\gamma_{gr} = 0$

Fig. 3. Intermediated model (SES Data). Legend: -- (dash–dash) Thai economy; --- (solid) simulation at estimated parameters, -- (dash–dot). Mean simulation, --(dot–dot) confidence intervals.

[Intermediated Model (SES Data). Notes: Source: Giné and Townsend (2004)]

Gine and Townsend (2004) Thailand

DISTRIBUTION OF GAINS

Gains depend on wealth and talent-need disb of each-
Rich hh sensitive to Interest rate, occupation choice
Not talented rich give up firms and save
Change in talent will change impact

Poverty Reduction: Laudable Goal
Here it is Linked to macro growth


[Welfare Comparison in 1979 (Townsend Thai data) Source: Giné and Townsend (2004)]
Once again, the model predicts a higher entrepreneurship rate for the sector of the economy without credit. The entrepreneurship rate for this sector does not vary substantially, whereas the entrepreneurship rate for the credit-enabled sector does vary a great deal, and again, increases noticeably in 2005.
Figure 7.6.2.5  Occupational partitions from data and model, 2000-2008 (metric #2)

Source: Own calculations, ENOE/ENEU
Figure 7.6.2.3 Model-predicted entrepreneurship levels in credit- and non-credit sectors, 2000-2008 (metric #2)

Source: Own calculations, ENOE/ENEU
Empirical Observations on Mexico and Thailand

Calibration

DSGE with Financial Sector

New models

Transition

DSGE: Greenwood-Jovanovic (JPE 1990)

Fig. 1.—Empirical implications

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DSGE: Greenwood-Jovanovic (JPE 1990)

- A model of financial participation
- Household $j$ maximizes

$$E_0 \left[ \sum_{t=0}^{\infty} \beta^t \ln \left( c_t^j \right) \right]$$

with three investment choices

- Riskless: $i_{t-1}$ at the end of period $t-1$ yields $\delta i_{t-1}$ in period $t$
- Risky: $i_{t-1}$ at the end of period $t-1$ yields $\left( \theta_t + e_t^j \right) i_{t-1}$ in period $t$
- Financial intermediary: $i_{t-1}$ at the end of period $t-1$ yields $r(\theta_t) i_{t-1}$ in period $t$, fixed-fee $q$
- Zero-profit condition for financial intermediaries implies

$$r(\theta_t) = \gamma \max(\delta, \theta_t)$$

$$q = \alpha$$
DSGE: Greenwood-Jovanovic (JPE 1990)

- Value function of individual $i$

\[
W(k_t) = \max_{s_t, \phi_t} \left\{ \ln (k_t - s_t) + \beta \int \max \{ \text{VNP}, \text{VP} \} \, dF(\theta_{t+1}) \, dG(\epsilon_{t+1}) \right\}
\]

\[
\text{VNP} = W\left(s_t \left( \phi_t \left( \theta_{t+1} + \epsilon_{t+1}^j \right) + (1 - \phi_t) \delta \right) \right)
\]

\[
\text{VP} = V\left(s_t \left( \phi_t \left( \theta_{t+1} + \epsilon_{t+1}^j \right) + (1 - \phi_t) \delta \right) - q \right)
\]

and $V(k_t) =$

\[
\max_{s_t} \left\{ \ln (k_t - s_t) + \beta \int \max \{ W(s_t r(\theta_{t+1})), V(s_t r(\theta_{t+1))) \} \, dF(\theta_{t+1}) \right\}
\]

- Equilibrium: Set of value functions $v(k_t), w(k_t)$, saving rules, $s(k_t)$ and $\phi(k_t)$ such that

  - choose to whether or not remain in the financial market $V(k_t) \geq W(k_t)$
  - choose to whether or not to stay independent $W(k_t) \geq V(k_t - q)$
Empirical Observations on Mexico and Thailand

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DSGE with Financial Sector

New models

Townsend and Ueda (Restud 2007)

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DSGE with Financial Sector

Townsend and Ueda (Restud 2007)

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GJ Model

- Model Economy

convert the capital investment $i_{jt}$ at date $t$ into a yield $y_{j,t+1}$ at date $t + 1$. One technology yields a safe but relatively lower rate of return $\delta$ per unit capital and the other gives a risky rate of return $(\zeta_{t+1} + \epsilon_{j,t+1})$ with higher expected value, where $\zeta_{t+1}$ represents a common aggregate shock and $\epsilon_{j,t+1}$ an idiosyncratic shock specific to agent $j$. The aggregate shock $\zeta_{t+1}$ is governed by a time-invariant uniform distribution with support $[\xi, \xi]$, and the idiosyncratic shock $\epsilon_{j,t+1}$ is governed by a time-invariant uniform distribution with support $[-\bar{c}, \bar{c}]$ with $E(\epsilon_{j,t+1}) = 0$. Let $\eta_{j,t+1} = \zeta_{t+1} + \epsilon_{j,t+1}$ be the composite shock, and $\Psi^n$ be its distribution function. GJ assume that the lower bound for the composite shock is positive, i.e., $\zeta - \bar{c} > 0$.

$$E \sum_{t=0}^{\infty} \beta^t \frac{C_{jt}^{1-\sigma}}{1 - \sigma}$$

Courtesy of Hyeok Jeong and Robert Townsend. Used with permission.
Estimation

• Likelihood Function

\[ d_{jt} = \begin{cases} 1, & \text{if } v^1(k_{jt} - q) \geq v^0(k_{jt}) \\ 0, & \text{if } v^1(k_{jt} - q) < v^0(k_{jt}). \end{cases} \] (30)

\[ d_{jt} = \begin{cases} 1, & \text{if } k_{jt} \geq k^* \\ 0, & \text{if } k_{jt} < k^* \end{cases} \] (31)

There is no closed form solution for \( k^* \) because there are no analytic solutions to the dynamic programming in (25). However, from the formulation of the dynamic programs in (25) and (26), it is clear that \( k^* \) is a function of the underlying parameters of the GJ model, \( \theta^{GJ} = (q, \delta, \beta, \sigma, \gamma, \zeta, \xi, \tau) \).

Courtesy of Hyeok Jeong and Robert Townsend. Used with permission.
That is, the participation decision of a previously non-participating agent \( j \) at date \( t \) with wealth \( k_{j,t-1} \) can be rewritten as

\[
d_{jt} = \begin{cases} 
1, & \text{if } \eta_{jt} \geq \eta^* \left( k_{j,t-1}, \theta^{GJ} \right) \\
0, & \text{if } \eta_{jt} < \eta^* \left( k_{j,t-1}, \theta^{GJ} \right),
\end{cases}
\] (33)

where

\[
\eta^* \left( k_{j,t-1}, \theta^{GJ} \right) \equiv \frac{1}{\phi \left( k_{j,t-1}, \theta^{GJ} \right)} \left[ \frac{k^* \left( \theta^{GJ} \right)}{i \left( k_{j,t-1}, \theta^{GJ} \right)} - (1 - \phi \left( k_{j,t-1}, \theta^{GJ} \right)) \delta \right].
\] (34)

The participation decision in (33) is stationary for a given wealth level because the composite technology shock \( \eta_{jt} \) is drawn from the time-invariant distribution. Thus once we solve the pair of functional equations in (28) and (29) to get \( k^* \) and the time-invariant policy functions \( \phi \) and \( i \), we can form a likelihood function in terms of model parameters \( \theta^{GJ} \).

In forming the likelihood function, the unobservable aggregate shock \( \zeta_t \) generates cross-sectional dependence over the individuals at a given date \( t \). Thus we first consider a conditional likelihood function \( L_t(\theta^{GJ}, \zeta_t) \) for a given aggregate shock \( \zeta_t \) and then integrate the aggregate shock out to form an unconditional likelihood function, as follows.

Courtesy of Hyeok Jeong and Robert Townsend. Used with permission.
Estimation, cont.

Given a series of serially independent aggregate shocks \((\zeta_t)_{t=1}^T\), the likelihood function can be factorized into marginal likelihoods:

\[
L(\theta^{GJ}, (\zeta_t)_{t=1}^T) = \prod_{t=1}^T L_t\left(\theta^{GJ}, \zeta_t\right).
\]  

(35)

Since the composite shock \(\eta_{jt} = \varepsilon_{jt} + \zeta_t\) is i.i.d. conditional on \(\zeta_t\), a conditional likelihood function \(L_t(\theta^{GJ}, \zeta_t)\) at date \(t\) is given by:

\[
L_t\left(\theta^{GJ}, \zeta_t\right) = \prod_{j=1}^{n_t} \left[1 - \Pr(\varepsilon_{jt} \leq \eta_{jt}^* - \zeta_t)\right]^{d_{jt}}\left[\Pr(\varepsilon_{jt} \leq \eta_{jt}^* - \zeta_t)\right]^{1-d_{jt}}
\]  

(36)

where \(\eta_{jt}^* = \eta^*(k_{j,t-1}, \theta^{GJ})\) in (34).

**Table 4. Estimated GJ Parameters**

<table>
<thead>
<tr>
<th></th>
<th>(q)</th>
<th>(\gamma)</th>
<th>(\beta)</th>
<th>(\sigma)</th>
<th>(\delta)</th>
<th>(\zeta)</th>
<th>(\zeta)</th>
<th>(\bar{\varepsilon})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5021</td>
<td>1</td>
<td>0.9627</td>
<td>0.9946</td>
<td>1.0479</td>
<td>1.0470</td>
<td>1.1905</td>
<td>0.9954</td>
</tr>
<tr>
<td></td>
<td>(0.0482)</td>
<td>(0.0000)</td>
<td>(0.0061)</td>
<td>(0.0926)</td>
<td>(0.0064)</td>
<td>(0.0451)</td>
<td>(0.0514)</td>
<td>(0.0355)</td>
</tr>
</tbody>
</table>

Courtesy of Hyeok Jeong and Robert Townsend. Used with permission.
Empirical Observations on Mexico and Thailand

Calibration

DSGE with Financial Sector

New models

Townsend and Ueda (Restud 2007)

Benchmark, best-fit

Higher $\theta$ Variance, best-fit

[ Benchmark, best-fit (left-hand graphs) and Higher Variance, best-fit (right-hand graphs). Source: Townsend and Ueda (2005)]

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**Table 2**

<table>
<thead>
<tr>
<th></th>
<th>1987-96 Growth Difference</th>
<th>Annualized Growth with Cost Reduction</th>
<th>Annualized Growth without Cost Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable cost reduction in 1987 (1.5% to 0%)</td>
<td>0.59</td>
<td>6.87</td>
<td>6.28</td>
</tr>
<tr>
<td>Entry cost reduction in 1987 (7 to 4.5 model unit)</td>
<td>[0.96]</td>
<td>[4.41]</td>
<td>[3.45]</td>
</tr>
<tr>
<td></td>
<td>[−0.14]</td>
<td>7.34</td>
<td>7.48</td>
</tr>
<tr>
<td></td>
<td>[−0.26]</td>
<td>[4.48]</td>
<td>[4.74]</td>
</tr>
</tbody>
</table>

**Note:** Iterated shocks are used in the simulation. Numbers in brackets are the results of alternative simulation, using the expected value of shocks after 1987.

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### Table 2. Spurious Regression Results: Long-Run Effects

<table>
<thead>
<tr>
<th>Estimation Method</th>
<th>1985 as initial period</th>
<th>1980 as initial period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.5110</td>
<td>7.0600</td>
</tr>
<tr>
<td>Financial Depth</td>
<td>4.7298</td>
<td>-36.0538</td>
</tr>
<tr>
<td></td>
<td>(1.7914)</td>
<td>(-31.0114)</td>
</tr>
<tr>
<td></td>
<td>-5.2447</td>
<td>-8.8110</td>
</tr>
<tr>
<td></td>
<td>(-1.8188)</td>
<td>(-4.2517)</td>
</tr>
<tr>
<td>Inequality</td>
<td>0.4324</td>
<td>0.4284</td>
</tr>
<tr>
<td></td>
<td>(1.0919)</td>
<td>(1.1932)</td>
</tr>
<tr>
<td>Initial GDP</td>
<td>0.9863</td>
<td>0.9942</td>
</tr>
</tbody>
</table>

### Table 3. Spurious Regression Results: Medium-Term Effects

<table>
<thead>
<tr>
<th>Estimation Method</th>
<th>1976–80 as initial period</th>
<th>1981–85 as initial period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Financial Depth</td>
<td>0.6599</td>
<td>0.6710</td>
</tr>
<tr>
<td></td>
<td>(0.0230)</td>
<td>(0.2501)</td>
</tr>
<tr>
<td>Inequality</td>
<td>4.9854</td>
<td>5.4020</td>
</tr>
<tr>
<td></td>
<td>(0.8192)</td>
<td>(0.8610)</td>
</tr>
<tr>
<td>GDP</td>
<td>-0.2008</td>
<td>-0.7181</td>
</tr>
<tr>
<td></td>
<td>(-0.4596)</td>
<td>(-0.9936)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.9601</td>
<td>0.9602</td>
</tr>
</tbody>
</table>

Notes: The dependent variable is 5-year average annual GDP growth, same as per capita growth. The independent variables are lagged variables. Robust t-statistics are in parentheses.

\[
Growth_m = \alpha_0 + \alpha_1 \text{Financial Depth}_m + \alpha_2 \text{Gini}_m + \alpha_3 \text{Log} (\text{Initial GDP}_m) + \nu_m. \tag{36}
\]

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Townsend & Ueda, *IER, 2010 -*

![Graph](image)

**Figure 21**

*Welfare gains from reduction in entry cost, 100,000 to 65,000 baht (7 to 4.5 model units)*

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Mexico: GDP Growth, 1989-2006
Empirical Observations on Mexico and Thailand

Mexico: Change in Inequality, 1989-2006

[Graph showing the change in inequality in Mexico from 1989 to 2006, with model predictions and observed data points.]
Variation in Thai Rural Wealth, 1988
Index of Wealth Based on Key Assets Aggregated to Thai Tambon Level

Wealth Index Per Tambon

0.00 - 0.27
0.28 - 0.43
0.44 - 0.62
0.63 - 0.84
0.85 - 2.3
No Data

Provinces In This Study
Major Thai Cities
Major National Highways

Model and Data Source: Principal Components Transform of 4 Key Household Assets, Computed by Yukio Koriyama, École Polytechnique, Paris

Figure 1
Village, Roads, Major Intersections and Amphoe District Center Locations

Figure 2

Legend
- Major Road Intersections
- Major Roads
- Village Locations
- Amphoe District Centers

Courtesy of John S. Felkner and Robert M. Townsend. CC BY-NC-SA
Figure 3

Enterprise at the National Level in 1986: CDD Survey Data

Local Moran Map (LISA - Anselin (1995)) of Statistically Significant Spatial Clusters

1986 Percent of Households Exclusively Engaged in Enterprise Aggregated by Amphoe (By Quintiles)

Red Areas are High Value Clusters
Blue Areas are Low Value Clusters

Entrepreneurial Income at the National Level in 1990: SES Survey Data

Local Moran Map (LISA - Anselin (1995)) of Statistically Significant Spatial Clusters

1990 Entrepreneurial Income Average Per Amphoe In Thai Baht (By Quintiles)

Courtesy of John S. Felkner and Robert M. Townsend. CC BY-NC-SA
ENTERPRISE CONCENTRATION 1986-1996
BIVARIATE LISA MAP
STATISTICALLY SIGNIFICANT
CONCENTRATIONS (P < .1)

Figure 6

Map is an output from a bivariate
Local Moran Index for 1532 villages,
considering 1986 fraction in enterprise surrounded
by 1986-1996 growth in fraction in enterprise

REDS are villages with higher
than average enterprise in 1986,
surrounded by villages with higher than
average growth in enterprise 1986-1996

PINKS are villages with lower
than average enterprise in 1986,
surrounded by villages with higher than
average enterprise growth 1986-1996

DARK BLUES are villages with lower than
average enterprise in 1986, surrounded by
villages with lower than average enterprise
growth 1986-1996

LIGHT BLUES are villages with higher than
average enterprise in 1986, surrounded by
villages with lower than average enterprise
growth 1986-1996

Legend

- Red: Areas where enterprise is continuing to concentrate
- Pink: New enterprise concentrations arising
- Light blue: Low enterprise areas
- Dark blue: Areas losing enterprise
- Major Roads

Courtesy of John S. Felkner and Robert M. Townsend. CC BY-NC-SA
Primary Estimation:
Occupational Choice Structural Simulation
Spatial Model:
M Parameter Varies Across Space
Bivariate LISA Map 1986-1996

ENTERPRISE CONCENTRATION 1986-1996
STATISTICALLY SIGNIFICANT CONCENTRATIONS (P = .1 OR LESS)

Legend
- **AREAS WHERE ENTERPRISE IS CONTINUING TO CONCENTRATE**
- **NEW ENTERPRISE CONCENTRATIONS ARISING**
- **LOW ENTERPRISE AREAS**
- **AREAS LOSING ENTERPRISE**
- **Major Roads**

Map is an output from a bivariate Local Moran Index for 1532 villages, considering 1986 fraction in enterprise surrounded by 1986-1996 growth in fraction in enterprise

REDS are village with higher than average enterprise in 1986, surrounded by villages with higher than average growth in enterprise 1986-1996

PINKS are villages with lower than average enterprise in 1986, surrounded by villages with higher than average enterprise growth 1986-1996

DARK BLUES are villages with lower than average enterprise in 1986, surrounded by villages with lower than average enterprise growth 1986-1996

LIGHT BLUES are villages with higher than average enterprise in 1986, surrounded by villages with lower than average enterprise growth 1986-1996

Figure 10

Courtesy of John S. Felkner and Robert M. Townsend. CC BY-NC-SA
Figure 18: Financial Deepening Simulation 1996 Credit Access Spatial Residuals

Differences are Between Actual and Simulated Window-Average Smoothed Values, Using 10 Nearest Neighbors

Reds are Areas of Model Over-Prediction, Greens are Areas of Model Under-Prediction

Figure 13 - 

Differences by Decile

<table>
<thead>
<tr>
<th>Major Roads</th>
<th>Differences by Decile</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.058524 - 0.300267</td>
<td>-0.058524 - 0.300267</td>
</tr>
<tr>
<td>-0.000266 - -0.094920</td>
<td>-0.000266 - -0.094920</td>
</tr>
<tr>
<td>-0.094919 - -0.000207</td>
<td>-0.094919 - -0.000207</td>
</tr>
<tr>
<td>-0.000266 - 0.000000</td>
<td>-0.000266 - 0.000000</td>
</tr>
<tr>
<td>0.000001 - 0.043563</td>
<td>0.000001 - 0.043563</td>
</tr>
<tr>
<td>0.043564 - 0.095989</td>
<td>0.043564 - 0.095989</td>
</tr>
<tr>
<td>0.095990 - 0.156081</td>
<td>0.095990 - 0.156081</td>
</tr>
<tr>
<td>0.156092 - 0.255348</td>
<td>0.156092 - 0.255348</td>
</tr>
<tr>
<td>0.255349 - 0.575134</td>
<td>0.255349 - 0.575134</td>
</tr>
<tr>
<td>0.575135 - 0.880695</td>
<td>0.575135 - 0.880695</td>
</tr>
</tbody>
</table>

Courtesy of John S. Felkner and Robert M. Townsend. CC BY-NC-SA
We find that the LEB occupation choice model captures reasonably well the observed patterns of aggregate income growth, in particular the sharp rise in income growth during the 1988-1992 period. This is accomplished without aggregate shocks. However, the underlying driving factor is a modification of the LEB model, which allows an exogenous expansion of an intermediated sector and consequent occupation shifts. The model also captures the inverted U-shaped Kuznets curve as observed in the data, via an eventually increasing wage, and hence a decrease in occupational income gap. The GJ model with endogenous financial deepening provides a reasonable fit to overall growth and inequality change at aggregate level, and fits the level of aggregate inequality better than the modified LEB model. On the other hand, GJ is missing the non-linear patterns of average income growth and expansion of the financial sector, and also the eventual downturn of aggregate inequality in the data.
“Growth and Inequality: Model Evaluation Based on an Estimation-Calibration Strategy” Jeong & Townsend, 2003

Both LEB and GJ correctly predict as in the data the existence of income differentials between key subgroups, i.e., entrepreneurs vs. workers/subsisters and participants vs. non-participants in the financial sector. Also both models predict as in the data that population shifts from the low-income subgroups to high-income subgroups contribute to income growth and changing inequality. But both models exaggerate these composition effects and also exaggerate the income divergence/convergence effects on inequality change, as the income gaps between subgroups in both models are too large.
## A.3 Summary Table

### 1. LEB

#### 1.1. Aggregate Dynamics

<table>
<thead>
<tr>
<th>Success</th>
<th>Failure/Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trends and movements of income level</td>
<td>Initial high growth</td>
</tr>
<tr>
<td>Movements of income growth rate</td>
<td>Lower inequality level overall</td>
</tr>
<tr>
<td>Inequality movements</td>
<td>Lower level of population share of entrepreneurs</td>
</tr>
<tr>
<td>Increasing population share of entrepreneurs</td>
<td>Population size ordering</td>
</tr>
<tr>
<td>Direction of changes in population composition</td>
<td>(too few non-participant entrepreneurs)</td>
</tr>
<tr>
<td>Higher fraction of entrepreneurs in the financial sector</td>
<td>(too many participant entrepreneurs)</td>
</tr>
<tr>
<td>Financial expansion onto growth (especially the upturn of late 1980's)</td>
<td></td>
</tr>
</tbody>
</table>

#### 1.2. Subgroup Dynamics

<table>
<thead>
<tr>
<th>Success</th>
<th>Failure/Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income of non-participant workers increases (though less than in the data)</td>
<td>Missing co-movements of growth rates across occupation groups before 1992</td>
</tr>
<tr>
<td>Capturing occupational income gap</td>
<td>Gap is too large</td>
</tr>
<tr>
<td>Non-participant entrepreneurs earn higher income than participant entrepreneurs</td>
<td>Missing the surge of income of participant entrepreneurs in late 80's and subsequent increase of income of non-participant entrepreneurs</td>
</tr>
<tr>
<td>Subgroup inequality levels are too low</td>
<td></td>
</tr>
<tr>
<td>Higher inequality among participants than non-participants</td>
<td></td>
</tr>
<tr>
<td>Inequality among participants decreases</td>
<td></td>
</tr>
<tr>
<td>Missing divergence between participant and non-participant groups</td>
<td></td>
</tr>
<tr>
<td>Fail to relate movements of aggregate income growth and inequality to growth patterns of the richest group, the participant entrepreneurs</td>
<td></td>
</tr>
</tbody>
</table>

#### 1.3. Decomposition

<table>
<thead>
<tr>
<th>Success</th>
<th>Failure/Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capturing compositional effects on growth and inequality change</td>
<td>Too large orders of magnitude</td>
</tr>
<tr>
<td>Signs of all effects on inequality change are right</td>
<td>Too large orders of magnitude (Due to too large occupational income gap)</td>
</tr>
<tr>
<td>(Increase in subgroup inequality and decrease in income gap via convergence)</td>
<td></td>
</tr>
<tr>
<td>Adding financial expansion helps decomposition effects to be closer to data</td>
<td>But not good enough and exogenous addition of financial sector creates other anomalies</td>
</tr>
</tbody>
</table>
1.4. Shape of Income Distribution

<table>
<thead>
<tr>
<th>Success</th>
<th>Failure/Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fail to predict overall shape of income distribution</td>
</tr>
<tr>
<td></td>
<td>Spike at the low end hence missing income variation among the poor</td>
</tr>
<tr>
<td></td>
<td>Missing the extremely rich</td>
</tr>
</tbody>
</table>

2. GJ

1.1. Aggregate Dynamics

<table>
<thead>
<tr>
<th>Success</th>
<th>Failure/Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trend and level of average income</td>
<td>Not capturing movements (stagnation and then upturn after 1986)</td>
</tr>
<tr>
<td>Trend and level of inequality</td>
<td>Not capturing movements (downturn after 1992) and over-predicts the increase</td>
</tr>
<tr>
<td>Trend and level of financial expansion</td>
<td>Missing nonlinear pattern of expansion (surge after 1986)</td>
</tr>
</tbody>
</table>

1.2. Subgroup Dynamics

<table>
<thead>
<tr>
<th>Success</th>
<th>Failure/Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average income of participants increases</td>
<td>Average income of non-participants stays constant</td>
</tr>
<tr>
<td>Income gap between participants and non-participants (LEB anomaly solved)</td>
<td>Missing co-movement of growth rates before 1992</td>
</tr>
<tr>
<td>Higher growth rates of participants than non-participants, hence diverging income levels between them (LEB anomaly solved)</td>
<td>Gap is too large</td>
</tr>
<tr>
<td>Inequality within participants increases (LEB anomaly solved)</td>
<td>Missing catch-up of non-participants after 1992</td>
</tr>
<tr>
<td></td>
<td>Too low subgroup inequality</td>
</tr>
<tr>
<td></td>
<td>Fail to relate movements of aggregate patterns of growth and inequality to the growth patterns of the richest group, participant entrepreneurs</td>
</tr>
</tbody>
</table>

1.3. Decomposition

<table>
<thead>
<tr>
<th>Success</th>
<th>Failure/Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capturing compositional effects on growth and inequality change</td>
<td>Too large orders of magnitude</td>
</tr>
<tr>
<td>Signs of across-group inequality effects are right</td>
<td>Wrong signs of within-group inequality effects</td>
</tr>
<tr>
<td></td>
<td>Too large across-group inequality</td>
</tr>
</tbody>
</table>

1.4. Shape of Income Distribution

<table>
<thead>
<tr>
<th>Success</th>
<th>Failure/Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall shape of income distribution</td>
<td>Missing middle class</td>
</tr>
<tr>
<td></td>
<td>Over-predicting poverty</td>
</tr>
<tr>
<td></td>
<td>Missing the extremely rich</td>
</tr>
</tbody>
</table>

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