Domestic trade impacts of the expansion of the National Expressway Network in China

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Note: The purpose of this presentation is to illustrate the general approach suggested for assessing potential economic benefits from expansion of the expressway system. While the general trends and spatial patterns presented here are considered to be robust, the exact magnitudes of impacts will likely be subject to (possibly significant) revision.
National Expressway Network (NEN)

- From 1990 to 2005, China completed nearly 41,000 km of high-grade tolled expressways.
- Approximately 400,000 km of local and township roads were also improved.
- This was achieved by investing upwards of US$40 billion per year – one third of that amount allocated to the development of the NEN.
Estimating benefits

• The main purpose of the exploratory work presented here is to assess a methodology for estimating possible domestic trade expansion benefits due to the construction of the NEN.

• The approach extends previous work for Africa and Eastern Europe & Central Asia to a subnational setting and is based on improvements in travel time estimates rather than distance measures.
Outline

• Presentation of the general approach
• Data
  – Road network information
  – Economic data
• Estimations
• Results
• Caveats and possible improvements
Overview of approach

• Policy question: By how much would inter-provincial trade in China increase after completion of the NEN?

• Develop a spatially explicit model of the Chinese road system connecting the most important cities before (base) and after expressway construction

• Estimate base line trade flows between provinces using information on total inflows and outflows for 24 provinces

• Determine suitable gravity trade model parameters to fit the trade model using travel times from the base network

• Predict trade flows between 113 major cities (> 500k population and provincial capitals) before and after NEN completion using travel times from the GIS network

• Determine predicted trade volume on each network link
Road network information

• Obtained a geographically referenced road network for China

• Significant additional cleaning and editing

• Determination of travel speed (design speeds) for each type of road network link

• Separation of base network vs. complete network that includes expressways

• 20,899 line segments in the base network; 31,538 with expressways (see maps on next slides)
Base network

Travel speed
- 10 - 15
- 16 - 30
- 31 - 50
- 51 - 75
Complete network
Complete network with expressways highlighted
113 cities above 500k population and provincial capitals, 2005 estimated population
Road network information

• Using standard network algorithms, we can compute a simple index of importance of each network link:

*The number of times each network link is used when we connect each city with all other cities along the fastest route through the network*

• (next slides) The faster speeds of the expressways “pull” traffic away from minor roads
Importance of network links

Base network

Importance: number of times link is used when connecting each city with all other cities; unused links not shown
Importance of network links
Base network + highways

Importance: number of times link is used when connecting each city with all other cities; unused links not shown
Road network information

• The average estimated travel time between provinces drops from 38.2 hours in the base network to 28.6 hours in the network that includes expressways (i.e., by 9.6 hours, median reduction is 8.5 hours)

• The maximum travel time decreases from 104.0 to 76.2 hours

• Travel times are GIS calculated and assume non-stop travel at maximum speed; actual times will be somewhat higher
Economic data

• There are no data on inter-provincial trade flows for China

• We do have total domestic imports and exports in 1997 for a subset of 24 of the 31 provinces that were derived from input-output models (kindly provided by Sandra Poncet, University of Paris-Sorbonne)

• We use these marginal totals of the trade flow matrix in a doubly-constrained spatial interaction model to estimate inter-province trade flows

• We then use these trade flows to estimate a standard gravity trade model
Gravity model

• Standard tool in trade economics (and in transport sector analysis)

• There will be more trade between provinces with larger economies (economic scale)

• There will be less trade between provinces that are further apart (distance or, in this application, travel time)
Gravity model

\( \hat{T}_{ij} = K \frac{E_i^{\beta_1} M_j^{\beta_2}}{d_{ij}^{\beta_3}} \)

where

- \( T_{ij} \) = trade flow between provinces \( i \) and \( j \)
- \( K \) = valuation constant
- \( E \) = exporter economic scale (usually GDP)
- \( M \) = importer economic scale
- \( d \) = travel time between province \( i \) and \( j \) (average travel time between all cities in the two provinces)
- \( \beta \)'s = parameters to be estimated
Gravity model

• After taking logs, the model estimated on inter-provincial flows is

\[ \ln \hat{T}_{ij} = -5.128 + 0.741 \cdot \ln E_i + 0.8735 \cdot \ln M_j - 2.016 \cdot \ln d_{ij} \]

• This model is then used to predict flows between all city pairs (except those that are in the same province) using first the base network travel times and then those of the full network (the exporter/importer GDP is held constant at 1997 levels)

• The difference between the aggregate estimates is the predicted trade benefit of the NEN
Aggregate results

• The estimations suggest that the shorter travel times made possible by the expressway network may increase total trade flows between provinces by 120 percent, all else being equal (i.e., based on 1997 provincial GDP)

• The trade volume increases by more than seven-fold if we also set the exporter/importer GDP to 2005 levels in prediction

• Rapid economic growth in China may thus contribute significantly more to trade increases than infrastructure; BUT: much of that growth was due to infrastructure improvements in the first place (difficult to separate these second order effects)
Network flow results

• Since we estimate city-to-city flows before and after NEN and since we know the least time route between each city pair, we can allocate the predicted flows to specific network links.

• The resulting maps (next slides) show the estimated trade volume on each network link.

• Interesting implication: The concentration of flows on expressways may affect smaller cities and regions that were previously part of the main national trading network.
Estimated flows
Base network and 1997 GDP

Zero flow network links not shown
Estimated flows
Express network and 1997 GDP

Zero flow network links not shown
Caveats and possible improvements

• The lack of trade flow data requires considerable imputation and consequently lower precision in the estimates than is common in international trade modeling

• We should explore whether additional data exist, e.g., IO tables for 2002, any actual information on trade flows, modal split for different economic sectors, etc.

• Many expanded gravity model specifications have been proposed in the literature; additional variables could enhance predictions (but: larger limitation is the lack of observed trade data)
Caveats and possible improvements

- The model could be expanded to include intra-provincial and international trade flows, which would significantly increase the estimate of total trade expansion.
- Since waterways and rail are important in China, a complete model should include these transport modes (for now we need to make assumptions about what portion of each economic sector’s imports and exports are likely to be transported by road).