Economic Modelling 34 (2013) 145–153

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/ecmod

Geographical simulation analysis for logistics enhancement in Asia

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ARTICLE INFO

JEL classification:
F15
O53
R15

Keywords:
Geographical simulation
New economic geography
Asia
Trade cost

ABSTRACT

This paper presents a simulation of the reduction of several components in trade cost for Asia and examines its impact on the economy. Our simulation model based on the new economic geography embraces seven sectors, including manufacturing and non-manufacturing sectors, and 1715 regions in 18 countries/economies in Asia, in addition to the two economies of the US and the European Union. The geographical course of transactions among regions is modeled as determined based on firms' modal choice. The model also includes estimates of some border cost measures such as tariff rates, non-tariff barriers, other border clearance costs, transshipment costs and so on. Our simulation analysis for Asia includes several scenarios involving the improvement/development of routes and the reduction of the above-mentioned border cost. We have shown that the contribution of physical and non-physical infrastructure improvements conducted together is larger than the sum of the contribution by each when conducted independently.

1. Introduction

It is becoming increasingly important to construct economic models better suited to analysis of Asia. It formed sophisticated international production networks during a period of dramatic activity during the so-called “Asian Miracle” in the early 1990s and during the severe currency crisis in 1997/1998. Asian factories churned out millions of different consumer products with world-beating price–quality ratios by sourcing billions of different parts and components from plants spread across a dozen nations in Asia. In short, as stated in Baldwin (2006), East Asian corporations set up “Factory Asia”. In order to grasp the complicated nature of Factory Asia and examine changes in its behavior, we need economic models that can accurately describe the economic mechanics and capture the important economic factors in Asia.

In constructing economic models for Asia, at least two viewpoints should be taken into consideration. The first one concerns the mechanics of new economic geography (NEG). NEG allows us to explore the impact of the reduction in trade costs on industrial distribution, which is developed by Fujita et al. (1999). Several studies have applied the mechanics of NEG in the computable general equilibrium (CGE) model in order to investigate such impact, mostly for Europe, where the trade cost has already been low for some time. For example, employing such a CGE model for Europe, Forslid et al. (2002b), Forslid et al. (2002a) and Bosker et al. (2010) examine the impact of trade cost reduction on industrial distribution. Compared to European and North American countries, Asian countries are characterized by relatively high trade costs. In Asia, even basic infrastructure such as well-paved roads tends to be less developed in many countries, and various kinds of border costs such as tariff and non-tariff barriers have remained at a high level. As a result, a reduction of trade costs would be expected to yield a more drastic change in industrial distribution in Asia than in Europe. Such a phenomenon can be captured well by the NEG model.

The second viewpoint concerns the use of detailed geographical units. As mentioned above, in Asia, basic infrastructure such as well-paved roads has remained less developed in many Asian countries, and even within one country there may exist huge gaps in the quality of infrastructure. Therefore, it becomes crucial to take into account the extent of connectivity not only across countries but also across, say, provinces within each country. This implies that it is necessary to conduct analysis at the sub-national level in order to examine the economic impact of changes in the important components of trade costs in the case of Asia. However, it is much more difficult to collect sub-national level data in less developed countries. Such data is not available in a ready-made format, unlike in European countries which have EUROSTAT. Indeed, although there are several papers analyzing the economic impact of trade cost reduction in the context of Asia (e.g., Francois and Wignaraja, 2008; Plummer and Wignaraja, 2006; Siriwardana, 2003; Urata and Kiyota, 2005), no studies have investigated such impact at the sub-national level. Without the NEG model at the sub-national level, in the case of Asia, it would be difficult to obtain more accurate simulation results of trade cost reduction.

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0264-9993/$ – see front matter
http://dx.doi.org/10.1016/j.econmod.2013.03.021

The purpose of this paper is to illustrate the impact of trade cost reduction on the Asian economy by employing a sub-national level model based on NEG. Our model comprises seven sectors, including manufacturing and non-manufacturing sectors, and 1715 regions in 18 countries/economies in Asia in addition to the two economies of the US and the European Union. The Asian countries/economies are Bangladesh, Brunei Darussalam, Cambodia, China, Hong Kong, India, Indonesia, Japan, Korea, Lao PDR, Macao, Myanmar, Malaysia, Philippines, Singapore, Taiwan, Thailand and Vietnam. In addition, the currently available routes consisting of highways, railways, sea shipment and air shipment are incorporated in our model. The geographical route of transactions among regions is determined by firms' modal choice which reflects the type of goods. The model also includes estimates of some border cost measures such as tariff rates, non-tariff barriers, other border clearance costs, transshipment costs and so on. Thus, our simulation model is a comprehensive one for examining the impact of broadly-defined trade costs. By applying the sub-national level data, which is drawn from various kinds of data sources including unpublished ones, to this model, we examine several scenarios involving the improvement/development of transport routes and the reduction of the above-mentioned border cost.

The remainder of this paper is organized as follows. In Section 2, the simulation model is presented. In Section 3, we provide our data sources and parameter values used in the simulation model. Section 4 explains our simulation procedures, and then the results of our simulation for the reduction of transport costs are presented in Section 5. Finally, we conclude this paper in Section 6.

2. Model

In this section, we explain the NEG model that we use in our simulation. Our model is multi-region and multi-sector and consists of the agriculture sector, five manufacturing sectors and the service sector. Our model allows mobility of workers within each country and between sectors. While the transport cost of agricultural goods is assumed to be costless, that of manufactured goods and services is assumed to be the iceberg type. Our theoretical foundation follows Puga and Venables (1996), which captures the multi-sector and country general equilibrium of NEG. Therefore, the explanation below is almost limited to equations in equilibrium. However, it is worth noting that our model differs from that of Puga and Venables (1996) in terms of the specification in the agriculture sector. We have explicitly incorporated land size in agricultural production and have kept agricultural technology as constant returns to scale.[1]

Nominal wage rates in the agriculture sector are derived from cost minimization in the agriculture sector subject to the production function of the agriculture sector:

$$f_A(i) = A_A(i)L_A(i)^{\alpha}F(i)^{1-\alpha}, \tag{1}$$

where $f_A(i)$ is the amount of agricultural product produced at location i; α indicates a labor input share, $A_A(i)$ is the efficiency of agricultural production at location i, $L_A(i)$ represents the labor inputs of the agriculture sector at location i, and $F(i)$ is the area of arable land at location i. Since the price of an agricultural good is the same in all locations, nominal wage rates in the agriculture sector in location i, which is expressed as $w_A(i)$, are the value of the marginal product for labor input as follows:

$$w_A(i) = A_A(i)\alpha\left(\frac{F(i)}{L_A(i)}\right)^{1-\alpha}. \tag{2}$$

Note that agricultural price is chosen as the numeraire so that it is identical across regions.

[1] For detailed derivations, see Puga and Venables (1996) and Fujita et al. (1999).

In order to capture the concentration of particular sectors, we assume that the firms in the manufacturing sector are monopolistically competitive, and their inputs are assumed to be labor and intermediate goods as in Either (1982). Manufacturing firms at location i produce their products using the composite of the labor and manufacturing aggregate, and their production functions are expressed as a linear function of production quantity with a fixed input requirement, $f_M + (m(v) / A_M(i))$, where f_M is a fixed input requirement, $m(v)$ is the quantity produced by a manufacturing firm indexed v and $A_M(i)$ is the location and industry specific efficiency of labor.[2] We assume that the technology is identical for all varieties and in all locations. The price of manufactured goods $p_M(i)$ is set as:

$$p_M(i) = w_M(i)^{\beta}G_M(i)^{1-\beta}/A_M(i),$$

where β indicates a labor input share, $w_M(i)$ is the nominal wage of the manufacturing sector at location i and $G_M(i)$ is the price index of manufactured goods at location i.[3] We assume that the marginal input requirement is supposed to equal to the price–cost markup. Consequently, the location of firms depends on two factors, i.e., the supply of the other manufacturing firms and the demand for manufactured goods. This relation exhibits the concentration of manufacturing firms in particular regions. The price index of manufactured goods at location i is expressed as follows:

$$G_M(i) = \left[\sum_{j=1}^{R} L_M(j)A_M(i)^{\sigma_M-1}w_M(j)^{-(\sigma_M-1)\beta}G_M(j)^{-\sigma_M(1-\beta)}T_{ji}^{M-(\sigma_M-1)}\right]^{\frac{1}{-(\sigma_M-1)}}, \tag{3}$$

where T_{ij}^{M} stands for the iceberg transportation costs from location i to location j for manufactured goods and σ_M is the elasticity of substitution between any two differentiated manufactured goods. $L_M(i)$ represents labor inputs of the manufacturing sector at location i.

In contrast to the manufacturing sector, the service sector may not require intermediate goods for production. We assume that the technology of the service sector only requires labor input and exhibits increasing returns to scale.[4] Its cost function can be expressed by $w_S(i)$ $f_S + w_S(i)\ (q_S(v) / A_S(i))$, where $q_S(v)$ is the quantity of services produced by a firm, $w_S(i)$ is the nominal wage of the service sector at location i and $A_S(i)$ is the production efficiency of the service sector at location i. The price of services is set as $p_S(i) = w_S(i) / A_S(i)$. The price index of services at location i is expressed as follows:

$$G_S(i) = \left[\sum_{j=1}^{R} L_S(j)A_S(i)^{\sigma_S-1}w_S(j)^{-(\sigma_S-1)}T_{ji}^{S-(\sigma_S-1)}\right]^{\frac{1}{-(\sigma_S-1)}} \tag{4}$$

where T_{ij}^{S} is the iceberg transportation costs from location i to location j for services and σ_S is the elasticity of substitution between any two differentiated services. $L_S(i)$ represents labor inputs of the service sector at location i. We choose the production units as the inverse of the consumption share of services. The number of varieties of services is decided from the equality of wage payment and the expenditure share of labor at location i.

[2] In the actual model, the manufacturing sector is divided into five sub-sectors. So, the subscript M consists of M_1 to M_5. For simplicity, these subsectors are represented as a group by the "Manufacturing" sector in this description.

[3] As in Puga and Venables (1996), inter-industrial linkage can be captured in our analysis. However, for simplicity we drop the inter-industrial linkage across manufacturing and keep the linkage within the same manufacturing sector.

[4] Kolko (2010) shows that "services industries that trade with each other are more likely to collocate in the same zip code, though not in the same county or the same state; in contrast, manufacturing industries that trade with each other are more likely to collocate in the same county or state but not at the zip code level". We describe this feature of services by not assuming the intermediate inputs from the own industry in services and avoiding intermediate inputs from the other regions.