The Tendency of Regional Integration in China:

Incentive, Pattern, and Growth

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This is a preliminary version. Comments are welcome!

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Abstract

We analyze the trend of regional integration (or local protection) in current China through exploring its effect on local growth rate. Given specified assumptions on the endogenous growth model refined from Chinese characteristics, we show that any form of economic integration always makes both regions better off. Even with completely local protection for commodities flow but having technology flow, the new balanced growth rates for two regions integrated are still higher that that under autarky, if both have different level of technology. However, in the poor region with assumed low level of technology its manufacturing sector will be reduced, and its human capital in the R&D sector will move out to the manufacturing sector, or to the R&D sector in the rich region if this flow is allowed. Under completely economic integration with free commodities and technology flow, the new balanced growth rate is higher and the human capital in the R&D sector in both regions will be same as before integration. That is the incentive for closer economic integration. The interesting thing we show is the possibility to have a worst situation that both regions have the same level of technology and there is completely local protection, and that both regions have different level of technology but one region focus on the gap of growth rates between regions. Then the balanced growth rate will be lower than that under autarky.

Key Words: Inter-regional Integration, Economic Growth, Chinese Economy

JEL Classification Numbers: O53, O57, O41, O11, O31

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1. Introduction

The China's economic reform has been proceeded more than twenty years. In some extent, this reform can be viewed as the process of decentralization and/or the redistribution of power between the central government and local governments. While this process brings some incentive to local governments to promote local economic growth and development, it also results in some negative effects, such as the local protectionism, increased regional income differences, and consequently, decreasing investment on local higher education and research and development (R&D), etc. Therefore, there raises a new question for the continuous China's economic reform: how to eliminate the negative effects without hurting the local government interest/incentive for regional economic growth. It could be the common problem faced by all transitional economies.

The original aim for the central government to implement such re-allocation of administrative powers is, of course, to promote nationally economic growth through giving the local government strong incentive to boost regionally economic growth. The modern history of China shows that, however, such adjustment of administration powers has been carried on several times since 1949, but the results are ambiguous. These facts imply that there are some deeper reasons beyond such administrative adjustment. Moreover, we observe there is significantly local protectionism causing fragmented markets with limited economic integration and widening gaps among different regions (say, GDP gaps). On the other hand, the theory of trade indicates that free trade will increase the welfare for both sides of trade, especially for a unified nation. Then in the point of view of the central government, the local protectionism should be prohibited.

However, it does not means that every region can be guaranteed to be better off after "opening" its door to others. That is the key of our problem: what is the incentive for local government to open its door? Does it really benefit from it? In the circumstance that local governments focus on their own economic growth, say, GDP growth, to request or enforce one region (government) to suffer its loss from inter-regional integration is very difficult for the central government, perhaps is impossible currently. That is also the reason that different kinds of local protectionism can exist. Moreover, even the central government could enforce a local government to implement some policy, which is significantly harmful for its own region but benefit for other regions, the final result could be still uncertain since the local government has enough motivation to do something to reduce its own loss from such activities. This is a kind of example of "principle-agent" type problem with unstable final result. So, what we attempt to do here is to find out what one region can get from economic integration, and what is the solution for every part on a steady state -- it is not only a Nash Equilibrium, but also the Pareto Efficiency. To solve the potential interest conflict and find out its Nash Equilibrium solution are our primary motivation for this paper.

Current dispute on the degree of such protectionism and its trend in China provides direct motivation to write this paper. Given existence of local protections in China, Young (1996, 2000) finds that the local protectionism has been increased with declining of regional specification after Chinese economic reform. He uses the evidence that increased transportation capacity with reduced transportation intensity in China (date: 1988-1994??) to support his conclusions: different regions will become more similar than before. On the other hand, Naughton (1999) argues that his data, which cites from input-output tables among Chinese provinces between 1987 and 1992, shows that the increasing regional specification with increased inter-provincial trade. That could be a puzzle in the empirical study for Chinese regional development, since they hold different data sets and no one can argue their empirical results based on their own data. There seems a need for an applied theoretical study as the complementary study for empirical studies to explore the incentive for the local protectionism, if it exists and consistent, and its trend, with the support of empirical evidence as modified assumptions. In this paper, we attempt to find a kind of explanation for it, since the theoretical analysis for inter-regional integration can explore some deeper reasons for local incentive for such integration.

Historically, people believe that the larger economy (i.e. larger domestic market in size) will bring the higher rate of economic growth. Then the economic integration should increase the growth rate for the new unified economy from such integration. Moreover, the opinion that any kind of restrictions to the flow of consumption goods, capital and knowledge will cause the growth rate diminish permanently is also popularly accepted by many economists. Due to technical difficulties, a rigorous model of growth cannot be given to describe and justify people's belief precisely. We know, however, some most important components in growth theory, therefore we are able to build some general models to examine such believe and approach our concerns. From the mid 1980’s the endogenous growth models represent the latest development in the field of economic growth. With such development, Romer and Rivera-Batiz successfully separate the flow of knowledge from the flow of goods and from the flow of human capital (Romer, 1990; Rivera-Batiz and Romer, 1991a, 1991b) (RRR, thereafter), which allows people to analyze the impact of each factor on the growth. This special structure of RRR’s model sheds some lights on solving our problem. Preciously, Romer and Rivera-Batiz find the effect of international economic integration on the growth depending on the R&D pattern for different scenarios of the flow of technological information and goods between two countries. Devereux and Lapham (1993, 1994) (henceforth DL) first introduce the dynamic analysis into the RRR model. Now, we attempt to explore the dynamic effect of some key conditions inducing local protection on regional economic growth and to find a stable growth solution for each region in inter-regional economic integration. The special characteristics of current China formed by our assumptions should enhance the rationality and feasibility of our results.

There are some restrictions as specific characteristics in China economy. They are crucial in setting up our theoretical assumptions. Moreover, theoretically, there are still unclear the effect of larger or integrated economy on economic. For example, Grossman and Helpman (1992) point out that the larger size of economy will bring faster growth if all factors supply increases at same ratio, or if elasticity of substitutes between factors in all manufacturing industries are greater one. So it is very difficult to judge whether it is good for China to have a unified economy for every regions in China. Empirically, it is also very hard to assume whether fragmented or unified market is in China now, because of severe restrictions on resources, for example, electricity.

Precisely, total market system and the supply of inputs and outputs in China are changed dramatically over last twenty years. The national goods market was divided by provinces, even smaller areas practically, and could be still divided implicitly at different extents by local protectionism for various considerations. For the factor market, the unskilled labour and human capital were strictly restricted to flow from one region to the other because of the existence of "Household Registration System" (Hu-ji-zhi), and are now allowed to flow practically. But cross-regional investment is still strictly restricted, while foreign investment, especially foreign direct investment (FDI) are unrestricted and even encouraged in any region in China. Although current economic development makes it change gradually, in most regions in China, except in some " Special Economic Zones" (SEZ, thereafter) and several "Coastal Opening Cities" (COC, thereafter), the requirement of completely free flows of physical capitals is not achieved. This situation above allows us to modify some theoretical assumptions and models, and to distinguish them from international integration.

In general, all we inquire here is to find the effect and tendency of regionally economic integration on the long-run economic growth based on their incentives and conditions within fragmented and/or unified markets. We wish this paper would provide a useful approach to think about the regional incentive to decrease the local protectionism with national welfare[1] increase. We also hope our theoretical analysis can provide some possible policy implications for governments.

Our paper is designed as follows. Section 2 will use the detailed specific characteristics of current China to set up/refine our basic assumptions and models. Section 3 will show the derived static and dynamic results and, discuss the reasons and policy implications in China under various scenarios. Section 4 will conclude our results, policy implication, and some potential further researches.

2. Basic Assumptions and Models

We set up and/or refine our basic assumptions and models in this section based on the empirical evidences from China. That ensures our theoretical results applicable to analyze China's facts and provide a rational base for policy implications. We discuss our basic models first.

2.1 Basic Models

We will justify our theoretical model based on the reality of China.

[1] We may define the national welfare as the long-run economic growth with non-expended regional income differences.

Inter-regional integration is not same as inter-regional trade, even the latter could plays a very important role in the former. However, for China, we need to examine all possible channels for such economic integration: inter-regional co-operation for some national projects, inter-regional investment, inter-regional trade. The first one becomes very limited because of the transition of central-planning system. Inter-regional investment is also limited given the current restrictions on cross-regional investment for China's firms (see Boyreau-Debray and Wei, 2002)[2]. That is why we focus on the inter-regional trade on the topic of inter-regional integration. The empirical evidence supports our above conclusion. Barry Naughton (1999) shows that the inter-provincial trade not only is most important for provincial GDP (both goods inflow and outflow take 70% of each provincial GDP aggregately for twenty-five provinces in China), but also is much more important than the international trade for all provinces surveyed (the ratios of inter-provincial trade to its GDP is about 2.5 to 3.5 times over those of international trade to its GDP) (see Table 1). Therefore, we can assume inter-regional trade is all we consider for the inter-regional integration in this paper.

Furthermore, for the inter-regional trade, there is still two issues needed to be distinguished. First, the inter-regional trade means goods trade concerning local industries, their competition status and their location. So, precisely, we should explore the relationship between industries in both regions, say, two provinces. Generally, regardless of local government’s attitude to trade and induced external investment, industry relation and distribution should be the core of regional integration since as the industry distribution in the region has been changed for some reasons, the circumstance of inter-regional trade and relevant policies designed to protect the local firms will be consequently changed. It seems to

[2] This kind of investment, however, will not be restricted by any local protectionists in capital inflow regions since it will increase employment and boom the local economy.

be a blind point for most researches on China, and perhaps on most regional development papers.

Second, inter-regional trade includes both inter-industry and intra-industry trade. If the former is more important than the latter, we prefer to use a trade model for such integration. If the latter is more important than the former, we prefer to deal with an endogenous growth model with massive trade for intermediate goods (inputs)[3]. For China, Barry Naughton (1999) shows that intra-industry trade is significant higher than inter-industry trade which goods traded are used as the final goods (see Table 2) in average. Therefore, in this paper, we adopt an endogenous growth model with economic integration between autarky economies to implement the inter-regional integration study in China.

The theory of trade already indicates that if significant differences exist in both trading parties, the both parties can gain from trade based on comparative advantage theory. Furthermore, Nancy Stokey found that "if a small open economy is either very advanced or very backward relative to the rest of the world, its rate of investment on human capital is lower under free trade than under autarky" (1991), when she set up a growth model with investment of human capital on individuals. All her conclusions can be inferred that when two countries with large difference on technology have trade, the both economies can gain from lower rate of investment on human capital with constant rate of growth. In this paper, however, we will focus on the growth problem which two regions economically integrated are similar, not significant differences. In fact, if two regions are great different, the local protectionism is less possible since there is the weak substitution between their goods. But it does not means our conclusions are invalid for the case of economic integration between

[3] Actually, both new trade model and endogenous growth model have involved both trade and growth (Krugman, 1979, 1989; Grossman and Helpmand, 1989a,b,c,d; Romer, 1986, 1990; Lucas, 1988; Rivera-Batiz and Romer, 1991, 1993). Here we just want to distinguish the relative advantage each model deals better with.

significantly different regions Stokey discussed above. Our dynamic approach will show the generality of our results.

The knowledge (or technology) advance is the engine of economic growth, as most growth economists agree. However, as Hu, Jefferson and Qian (2003) distinguished, there are three possible different channels to promote Chinese technology upgrade as a whole. There are: (1) Foreign Direct Investment (FDI) and its possible knowledge spillover; (2) technology transfer; (3) domestic R&D. For one channel of technology advance, there should be a specific model to match it. Hu, Jefferson and Qian (2003)'s empirical results indicate that within Chinese industries the contributions from these three channels are greatly different, based on the annual survey of Large and Medium Size Enterprises (LME) conduced by China's National Bureau of Statistics (NBS). The data "spans a period of five years from 1995 to 1999 and includes data for 29 two-digit manufacturing industries and over four-digit industries" (Hu, Jefferson, and Qian, 2003). The technology transfer, regardless of its sources (domestic or foreign), will affect the productivity only through domestic R&D. The FDI does not show its usefulness for adopting foreign technology transfer[4]. Moreover, the patentable knowledge totally comes from domestic R&D. Therefore, we can simple assume the R&D is the only source for knowledge (technology) creation.

Now we need to overview main theoretical R&D models and choose one that is suitable for current China. There are several specifications for the R&D modelling. More specifically, the RRR model has two specifications: the first one is the "Knowledge-driven" (KD) model:

$$\dot{A} = \delta HA, \tag{1}$$

where: A is a measure of knowledge including general theoretical knowledge and practical skill accumulated, and δ is a positive constant.

[4] It could be because of the quality of FDI in China. We will find more about this issue when we discussed the relationship between labor and FDI later in this section.

This means that Romer and Rivera-Batiz thought that the increasing of knowledge comes from the work of well-educated intelligent people with all existing knowledge. Therefore, if there are smart people with knowledge, then the new knowledge will be produced continuously without significant inputs of unskilled labour and physical capital goods.

The second is the "Laboratory-Equipments" (LE) model:

$$\dot{A} = B^{*} H^{\alpha} L^{\beta} \int_0^A x(i)^{1-\alpha-\beta} di, \quad \text{where: } B>1$$

(2)

This model shows that R&D needs all inputs which used in the manufacturing sector, but the knowledge has not directly productive value, except the knowledge works as a capital good when all capital goods are homogenous, i.e., x(1) = x(2) =...= x(i) = A.

When we, theoretically, examine the rationality of these two specifications in the R&D sector in the RRR framework and justify them in general, we should think about the relationship between the knowledge and other factors. The LE model looks quite general for the production of the knowledge, but it shows the relative importance of unskilled labor comparing with other factors. It seems not popular in the R&D sector in the past or current time, however, since many people think the importance of unskilled labor for producing knowledge is small enough and should be ignored. Moreover, when we recognize that the R&D production is also different from the intermediate inputs production, while the former only concerns the "ideas" creation, the LE model seems to be inappropriate.

To simplify the R&D process, the KD model is reasonable because people just attempt to catch the key factors in the production of the knowledge. The human capital plays, of course, the key role in such production, comparing to the unskilled labour in technological creation. It is another advantage for the KD model when it shows the difference between the production of knowledge and of goods, since we use the general Cobb-Douglas model to format the manufacturing sector that include all important inputs.

Moreover, the KD model has some empirical support. Xu (2003) finds that in many developing countries the domestic R&D is the main source of their economic growth which seems strengthen Hu, Jefferson and Qian's results (2003). Therefore, we prefer the KD model to show R&D sector theoretically.

Given all above theoretical R&D models, our task becomes to identify which specification for the R&D sector is suitable for China. First of all, let us see the R&D in the Chinese industries. Considering the role of China's 22,000 large and medium-size enterprises (LMEs) in Chinese economy. They are accounted for a small proportion of China's nearly 8 million industrial enterprises but contribute one-third of China's total industrial output. Moreover, most of them are to the State-owned enterprises (SOEs) Jefferson et. al. (2002) find that R&D activities are mostly conducted by SOEs comparing to all other enterprises. The R&D conducted by LMEs should represent the major part of the R&D in Chinese industries. We may approximately assume the R&D in China is conducted by SOEs or LMEs.

There are some interesting phenomena in empirical studies for China. On the one hand, Jefferson et. al. (2002) test their "knowledge production function" with some empirical models to examine the R&D performance in Chinese industries while they assume R&D expenditures include expenditures on labor, capital, and intermediate inputs (their "labor" should be interpreted as human capital in our framework). So the capital should be a very important factor for the R&D production. From the point of view of ownership types, they find that "R&D performers are more concentrated among SOEs and shareholding companies and least concentrated among foreign and overseas enterprises". Here SOEs indicates the LMEs above. Since the most of current FDI in mainland China is conducted by Hong Kong, Taiwan and Marco enterprises (HKT), they take the main part of foreign companies. And the contribution to the R&D from HKT enterprises is limited. It can be revealed by the different results from Gao (2002) and Cheng and Kwan (2000)'s papers. Cheng and Kwan (2000) find that there is little evidence to show the relationship between labor quality and the FDI in China using the data from 1985 when HKT enterprises can be viewed as the representative of the foreign enterprises from any aspect, since the other foreign firms from developed economies did not enter China massively. For these HKT firms, the technology they used is not advanced generally. The capacity and incentive conducting the R&D are not high as well. This is why Cheng and Kwan's results (2000) are different from Gao's (2002) which shows the clear relationship between labor and FDI. Some FDI from some developed countries could have the significant impact on technology in the future and gradually change the current situation, which is Gao (2002) emphases. There is not, however, strong evidence to prove the clear relationship between technology transfer and FDI even for those FDI from developed economies. Therefore, currently, we could still assume the SOEs, especially LMEs is the main force to conduct the R&D in Chinese industries.

On the other hand, Jefferson and etc. (2002) find that SOEs have the lowest efficiency in the knowledge production. However, "once they acquire new knowledge, SOEs appear to be able to use the innovations as effectively, or sometimes more so, than enterprises of other ownership forms" (Jefferson and etc., 2002). This fact reveals some difficulty in transition of knowledge production. Human capital could be a problem, but it is always our concern in the knowledge production. In fact, we will discuss the effects of different initial levels of the R&D and human capital on the economic growth. The role of physical capital becomes an important criteria for us to adopt different specifications of R&D activities in China in the knowledge production. The fact that SOEs, especially LMEs have incurred financial difficulty is not the surprising news. In particular Boyreau-Debray and Wei (2002) reveal that inter-regional capital flow in China is very difficult and China is not like a unified nation for the aspect of capital flow. The capital flow in China is similar to that within OECD nations. It shows SOEs are difficult to finance the R&D activities. This fact could explain why Chinese industries in general are at the low level of technology and lack of capacities to conduct the R&D activities. The problems for Chinese firms incurred to expand overseas market in color TV sets, refrigerators and other electronics can be good examples for our foregoing analysis. In this circumstance, we assume the suitable model for the R&D sector in current China is the KD model above.

There is one more reason to choose the KD model to represent the R&D activity in China. As a result of the application of the previous central-planning model for development, most of R&D activities in China concentrate in universities and academic research institutions belonged to the central and provincial governments. The civil, independent research institutes and private-sector-owned institutes are very few. With the current institution reform in governments, the research institutes attached to governments will be reduced sharply in magnitude. In the meantime, the emerging enterprises and the limited foreign firms could not establish their own research institutes quickly in recent future due to their view, financial capacity, and political situation. Therefore, universities will still be the centre of R&D activities in the near future. In this way, the change of both investment and initial level of R&D activities on higher education can be considered as the change of both investment and initial level of knowledge on the R&D sector. For universities that focus more on scientific research, the existing knowledge and human capital are much more important than others.

For the manufacturing sector, we still follow the general assumption of production most people including RRR (1990, 1991a) used: the Cobb-Douglas production function with fixed prices of all goods. Therefore, the relationships can be expressed in following functions.

$$Y = C+K \tag{3}$$

$$Y = H^{\alpha} L^{\beta} \int_0^A x^{1-\alpha-\beta}(i)di \quad (4)$$

$$K = \int_0^A x(i)di \quad (5)$$

where: Y is the output, C is the aggregate consumption goods, H is the human capital,

K is the aggregate capital goods, L is the labour used,

i is the index and a continuous variable, x (i) is the set of capital goods of type i used, A is the index of the most recently invented goods, so, x (i) = 0 for all i>A,

For the intermediate goods, however, we still keep RRR's assumption that there is monopoly in the short run due to latest knowledge protection and unique capital goods. On the household side, there is also a general utility function. Specifically, we can assume a basic utility function in the infinite horizon is as follows:

$$U(C) = \int_0^{\infty} e^{-\rho t} u(C(t))dt \text{ where } 0 < \rho < 1, \quad (6)$$

where: C is the consumption.

Particularly the utility function with the assumed CRRA preference is adopted:

$$U(C) = \int_0^{\infty} \frac{(C(t))^{1-\sigma}}{1-\sigma} e^{-\rho t} dt, \qquad \text{where } 0 < \sigma < 1 \quad (7)$$

In the dynamic environment, we assume both regions supposed to be integrated economically have the KD model for both R&D sectors. Therefore, we will explore the dynamic result from the R&D integration in the form of KD – KD in the next section, which also meets our previous assumption confined in the integration between similar regions.

2.2 Basic Assumptions

We follow most of assumptions RRR assumed. Except assumptions mentioned already in models, we should add the specific assumption for R&D activities in China. In the past, Chinese governments have invested much on their research academies and universities for long times. The impact for such long-run policies is still significant. Generally, this kind of investment to government-sponsored research academies and universities is much more than that to industries obtained in terms of R&D activities. Now we discuss the potential change of such investment on R&D from both non-profit (e.g. universities) and industry.

In research academies and universities, since the current investment for higher education comes from the central government budget directly, we could have a reasonable forecast for the future change of such investment on higher education. Currently, the rich regions have most universities and most of them are famous and outstanding. The relative poor regions have fewer universities and those qualities are relative lower and the funding from governments' investment is relative less. In the future, when local governments gain more power on their own business, as expected, including universities in their regions, the universities within rich regions will be expected to gain at least as much financial support from governments, and perhaps, enterprises as they obtain currently. On the other hand, the universities in the relative poor regions will be expected to obtain less research fund comparing to the financial support obtained before and that other universities in rich regions obtained. This forecast should be reasonable not only because the investment from the central government is continuously decreasing and the process of transferring the power to manage universities from the central government to local governments is also continuing, but also because the local sustainable development and growth will depend on the R&D in these universities, and the universities have contributed more and more to the local economic development.

Among Chinese industries, the situation is very similar. We can see that many large firms are concentrated in rich regions, which are much more than those in poor regions. As

Jefferson and etc. (2002) show, “R&D performers are more concentrated among capital-intensive firms with large sale volumes”, in which “large enterprises” are defined by China’s National Bureau of Statistics (NBS). Therefore the conclusion for the distribution of R&D activities in China from the university side is still same as that from industry side. Moreover, with the different initial levels of R&D (i.e. knowledge) among regions, such differences have some trend to be expanded. This fact becomes one of our assumptions in the following analysis: there are the different initial levels of R&D among regions. As the matter of fact, one of our purposes in this paper is to discuss the dynamic effect of the R&D conditions (such as, the initial levels) on the regional and national economic growth in long run, given such assumptions.

The labor mobility in current China may be thought as the free flow in the reality, whatever for unskilled or skilled labor that could be treated as human capital in some cases. There is a dispute about the relationship between labor quality and FDI, when Gao (2002) finds the positive relationship between labor quality and FDI and Cheng and Kwan (2000) did not. Fortunately, this dispute will not affect the labor and human capital supply for the production. So we do not need to add some assumption on labor and human capital.

Capital is always an important factor in manufacturing, and probably in the R&D productions. Fortunately, in our model, since we adopt the KD model for the R&D sector, capital will not directly involve the knowledge production based on Boyreau-Debray and Wei’s (2002) empirical results. However, the restriction on capital mobility in manufacturing factor is still a potential problem. On the other hand, the entrepreneurs, whether in the manufacturing or in the R&D sector, can set up their new companies in other regions which can avoid the problem resulted from the restrictions on inter-regional capital flow. Actually, many Chinese companies did this kind of “investment”. But it is not the case for universities and government-sponsored research institutions. Therefore, we assume that the manufacturing production for each region is kept in its region during inter-regional integration. Diminishing the local protectionism only means free goods flow.

We also assume that each region, regardless its richness, is viewed as a "small open economy" within China, so the interest rate is assumed to be same in a unified nation regardless of any restriction on inter-regional capital flow.

3. The Transitionally Dynamic Effects of Chinese Regional Integration on Growth

Since the economic integration we assumed is in form of R&D integration: KD-KD for the R&D sector, we have the following analysis for different integration patterns. The first pattern we discussed is the completely local protection, which sets up trade barrier to block all the goods flow, while knowledge flow still free.

3.1 Pattern 1 : Integration with Completely Local Protection for Goods Trade

We keep all DL's assumptions (1993, 1994), that is, keep all RRR's assumptions except allowing the different levels of knowledge in different regions. Then the production function in the manufacturing sector is:

$$Y = H_Y^{\alpha} L^{\beta} \int_0^A x^{1-\alpha-\beta}(i)di \qquad (8)$$

Here, we hold that labor supply is perfect inelastic, then L=1 in this section. $H = H_A + H_Y$, where H, H_y, and H_A are the employed human capital in one region as a whole, in manufacturing sector, and in R&D sector, respectively. The definitions for A, x, and i are same as before. Therefore, $K = \int_0^A x(i)di$ is the total physical capital stock in a region.

The K-D model gives the production function for R&D sector.

$$\dot{A} = \delta H_A A = \delta(H - H_Y)A \tag{9}$$

The RRR's balanced growth rate for an isolated economy itself is followed as:

$g = (\delta H - \Lambda\rho)/(\Lambda\sigma + 1)$, where $\Lambda = \alpha(\alpha + \beta)^{-1}(1 - \alpha - \beta)^{-1}$

The capital good, which is assumed as symmetry between any pair of capital goods, is:

$$x = \{[(1 - \alpha - \beta)^2 \phi^\alpha + \sigma\delta\phi]/[\rho + \sigma\delta H]\}^{(1-\alpha)/(\alpha+\beta)}$$

(10)

where: $\phi = [(\alpha(1 - \alpha - \beta))/(\delta(\alpha + \beta))]^{1/(1-\alpha)}$

Moreover, in these two assumed identical regions, autarky levels of g and x for each region are the same, but their stock of technological knowledge are different since the technological knowledge is assumed as region-specific, according to DL assumed.

Thus we adopt DL's assumptions to explain further for the growth effect in the case of asymmetric technology between regions. We define the share of one region's knowledge in the two-region total knowledge stock is:

$$\theta = A/(A + A^*), \tag{11}$$

where: * indicates the other region's variables.

Then we have:

$$H_Y = \psi P_A^{-\frac{1}{(1-\alpha)}} \theta^{\frac{1}{(1-\alpha)}} x^{\frac{(1-\alpha-\beta)}{(1-\alpha)}} \tag{12}$$

$$H_Y * = \psi P_A^{-\frac{1}{(1-\alpha)}} (1 - \theta)^{\frac{1}{(1-\alpha)}} x *^{\frac{(1-\alpha-\beta)}{(1-\alpha)}} \tag{13}$$

where P_A, as the value of new patent for patent holder, is common across two countries.

When θ =1/2, since the national market clearing and no depreciation on physical capital are assumed, we have the solution of g for our symmetric balanced growth path (i.e. SBGP):

$$\hat{g} = \frac{2\delta H - \Lambda\rho}{\Lambda\sigma + 2}, \qquad \text{where } \Lambda = \alpha(\alpha+\beta)^{-1}(1-\alpha-\beta)^{-1} \tag{14}$$

The capital good x for our SBGP path:

$$\hat{x} = \left[\frac{2^{\frac{\alpha}{1-\alpha}}(1-\alpha-\beta)^2\phi^{\alpha} + 2^{\frac{1}{1-\alpha}}\sigma\delta\phi}{\rho + \sigma\delta H}\right]^{\frac{1-\alpha}{\alpha+\beta}} \tag{15}$$

where: $\phi = [(\alpha(1-\alpha-\beta))/(\delta(\alpha+\beta))]^{1/(1-\alpha)}$

So, we have that under the new situation, both g and x are changed. Assuming ρ<1, σ <1, Λ>1, δ >>1, H>>1, we can see that the new g will fall down slightly if α >1/2, and g will go up slightly if α <1/2, comparing to g in autarky. While α is changed, however, g from (14) is not changed significantly.

The new capital good, x, from (15) increases and becomes greater than the x from (10) in the complete closed economy, without technology and goods flow, for the home region, but less than the corresponding x from the DL results under the case of goods flow only. It shows that opening communication on technological knowledge will increase the output of capital goods. That is, opening communication on technological knowledge is less important than opening goods flow. It shows the local protection causes more damage than blocking human capital flow and idea flow. However, the effect of opening communication on technological knowledge alone on the output of x is less significant than that of opening flow of goods alone, while both of DL's goods flow alone and our Pattern 1 (i.e. completely local protection) are considered as the different situations of partially inter-regional economic integration.

Moreover, we can show that all of these results based on the condition of $\theta = 1/2$ could NOT be held when $\theta \neq 1/2$. Precisely, when $\theta \neq 1/2$, we can see from (12) and (13) that when $A^* > A$, that is, $\theta < 1/2$, we have $H^*_y > H_y$. This result is opposite to DL's result under opposite situation. This means that for common values of P_A and same amount of x, when the other region has more stock of technological knowledge, its wage will has higher than that in one region (as the home region). It happens since the wage is equal to the marginal value of product of labor in same sector, and opening flow of technological knowledge allows the same marginal value of product of labor in R&D sector in each region, which leads the same marginal value of product of labor in manufacturing sector in each region. It is not the end of story. The dynamic analysis gives us the following theorems for it.

THEOREM 1. *For the situation of complete local protection for commodities in two-region Chinese economy (i.e. free flow of ideas without commodities flow in China), there does not exist the same balanced growth path for different regions when both regions have different technological levels. Especially, when the region has less technology stock, it will focus on R&D sector. When the region has more technology stock, it will focus on manufacturing sector.*

Proof: see Appendix.

These conclusions tell us that in China assumed as a two-region-economy, if the home region's initial stock of technological knowledge is less than the foreign's, the home region with lower initial level of technology will lose its share of R&D in both regions (or the integrated economy) gradually, and theoretically, its output in R&D sector will reduce to zero, while all new technologies will come from the other region eventually. However, it does not mean that the home region will produce all of manufacturing products in both regions (or the integrated economy), since the other region will still produce some capital goods with all of new designs.

This result occurs not only in the current situation that no commodities flow with free technological knowledge flow, but also in the opposite situation with free goods flow and no flow on knowledge (see Devereux and Lapham, 1994). But, we can see that our result from THEOREM 1 for current situation is different from DL's prediction (Devereux and Lapham, p.305,1994).

Moreover, we can prove that although under Pattern 1, the SBGP is unstable when θ ≠1/2, the real balanced growth rate and its real output of capital goods under such situation, will be higher than those in autarky (see Appendix for proof).. This result could be more important than human capital flow for each region.

3.2 Pattern 2: Complete Integration with Free Flow of Knowledge and Commodities

We still in the circumstance of K-D model, thus the basic assumptions such that (14) and (15) are still held. The results from the RRR model such as (10) are also kept for this section. However, the change of conditions concerning regionally economic integration causes the change on the equations of "equal wages":

$$\alpha H_Y^{\alpha-1}[\int_0^A x(i)^{1-\alpha-\beta}\,di + \int_0^{A^*} x(i^*)^{1-\alpha-\beta}\,di^*] = P_A(A+A^*)\delta \tag{16}$$

$$\alpha H^{*\,\alpha-1}_Y[\int_0^A x^*(i)^{1-\alpha-\beta}\,di + \int_0^{A^*} x(i^*)^{1-\alpha-\beta}\,di^*] = P_A(A+A^*)\delta \tag{17}$$

We get the new expressions for the human capital in both regions:

$$H_Y = 2^{\frac{-(1-\alpha-\beta)}{(1-\alpha)}} \psi P_A^{-\frac{1}{(1-\alpha)}} x^{\frac{(1-\alpha-\beta)}{(1-\alpha)}} \quad (18)$$

$$H_Y{}^* = 2^{\frac{-(1-\alpha-\beta)}{(1-\alpha)}} \psi P_A^{-\frac{1}{(1-\alpha)}} x^{\frac{(1-\alpha-\beta)}{(1-\alpha)}} \quad (19)$$

where P_A, as the value of new patent for patent holder, is still common across two countries. Then we have the following proposition:

<u>THEOREM 2</u>. *For the situation of complete inter-regional economic integration (i.e. free flow in both commodities and ideas) in two-region Chinese economy, regardless of the initial levels of technology in both regions, the human capital used in both sectors are always same, given the same human capital in both regions.*

Proof: Follow (18) and (19) directly.

The conclusion from this theorem is different from those under DL's work and Pattern 1 above. Intuitively, it means that in the situation of complete regionally economic integration, because the free flows of capital goods and knowledge cause the equal wage in both sectors of both regions, the stock of human capital in the R&D sector in each region will be allocated as same during economic integration. The possible different stocks of technological knowledge in each region will have negligible effect on the human capitals on the R&D sector in each region.

Since we obtain the following result for the change of θ:

$$\frac{\dot{\theta}}{\theta} = \delta(1-\theta)(H_y - H_y^*) = 0 \quad (20)$$

Then we have the following theorem.

<u>THEOREM 3</u>. *The share of technology for each region will no be changed during economic* *integration. Therefore the balanced growth path (BGP) is same for both regions and is globally stable regardless of the initial level of technology in each region. .*

Proof: Follow (20) directly to have $\theta = 0$.

This result sounds surprising in some way. But it is reasonable, if we see the fact that the human capital in the R&D sector in each region is always equivalent, or we consider it further that the fully free flows on goods and technological knowledge make the relative knowledge in each region keep unchanged, especially under our assumptions of wages in all sectors in this two-region Chinese economy are the same (see (16)-(17)).

As we did before, we assume that after economic integration, the SBGP allows θ = 1/2. Under this condition, we obtain the solutions for such SBGP:

$$\hat{\hat{g}} = \frac{\delta H - \Lambda\rho}{1 + 2^{-(1-\alpha-\beta)}\Lambda\sigma}, \qquad \text{where } \Lambda = \alpha(\alpha+\beta)^{-1}(1-\alpha-\beta)^{-1} \tag{21}$$

$$\hat{\hat{x}} = \left[\frac{2^{\frac{\beta}{1-\alpha}}(1-\alpha-\beta)^{\frac{2}{1-\alpha}}\phi^{\alpha} + 2^{\frac{-(1-\alpha-\beta)}{1-\alpha}}\sigma\delta\phi}{\rho + \sigma\delta\phi}\right]^{\frac{1-\alpha}{\alpha+\beta}}, \tag{22}$$

where: $\phi = [(\alpha(1-\alpha-\beta))/(\delta(\alpha+\beta))]^{1/(1-\alpha)}$

Since we adopt the DL model for their dynamic method to examine the stability of the SBGP, we find that the result of θ = 0 in (20) is independent of rest of the parameters of the dynamic system, i.e., θ = 0 has not been affected by the values of x, P_A, θ, and c. Therefore, we can say that the SBGP is globally stable, since the value of θ will be unchanged over time, as Devereux and Lapham predicted before (Devereux and Lapham, p.305, 1994). It should be additional good news for each region that their human capital will not flow out. So if the rich region leader does like the same growth rate as the poor region has, he/she could be happy to see their human capital, as called "ren-cai" in Chinese, will be kept.

Here we will compare these solutions above under the circumstance of complete integration between two regions (i.e. Pattern 2) with those under Pattern 1 as follows.

THEOREM 4. *The new balanced growth rate in the circumstance of complete economic integration between two regions will exceed that in each complete local protected region. The output of each capital goods becomes also higher in the circumstance of complete economic integration.*

Proof: see (14) and (15), and (21) and (22).

4. Concluding Remarks and Further Research

If regional economies in China, say, two regions, integrate when their R&D sectors are in the form of K-D model, we can have the following conclusions.

With completely local protection defined as no goods flow and having ideas flow only between these two regions, if the home region is the relatively poor region in the technology level (i.e. the assumed lower level of technology), it can take the rich partner's advantage to obtain more technological knowledge. However, as the result, all human capital in the home region will move to the R&D sector, since the other region, the rich one, will focus on the manufacturing sector to protect their own interest. It decreases the home region's growth rate in account since its manufacturing output is decreased. The R&D activities as a whole will be, however, reduced dynamically. That is, since both trading partners will suffer in the long run for the reduced growth rates. The interesting thing is that in this case, since technology levels are not same, both regions have the different growth rates. Therefore there is a possibility that one region could suffer its own interest (i.e. growth rate) to achieve its goal to keep/increase the gap of growth rates between regions. It could be the worst situation for the inter-regional integration in practice and could be the real reason behind the local protectionism behavior, since the two regions, as we assume, are not significantly different and each could be the leader (on the growth rate) in the future. Our further research will focus this. On the other hand, if both regions do not care about the human capital move and possible labor division, the myopic “local protection” will cause each partner focus on its comparative advantage and still have relative high growth rates for both. It means that both regions will have higher balanced growth rates, which are higher than the rates of each region having before integration. It could explain the fact that even some region attempts to protect itself, it still prefer have some integration with other regions.

Moreover, it does not mean the integration is always good for both sides. We can see that in the situation with local protectionism, if two regions have the same stock of technology, it is the worst situation theoretically: the balanced growth rate is lower than that of close economy (i.e. autarky). In this special case, the local protection as a partial integration could be a bad decision for both regions.

Without local protectionism, there is a sustainable growth rate for both regions, which is higher than that with the local protection for each region.

There are some good things for both regions, especially for the poor region that has the strong incentive to protect its own firms and industries. In the circumstance of complete integration without any protection, the human capital in one region will not move to the other region whatever the initial level of technological knowledge for each region is. Moreover the new balanced growth rate will be higher as mentioned above. That could be the important incentive for each region to give up their local protection. All policy implications for our conclusions should depend on the local leaders’ preference on own growth rate, the difference of growth rates, which are determined by the central government’s policy, and their attitude for the human capital flow.

There are some suggestions for further potential research. First of all, the specified R&D model for each region should be examined by empirical testing. The author does not find directly testing for each region, even through Jefferson (1999, 2000, 2002) did significant work on China's R&D sector in general. Secondly, the role of FDI and direct technology transfer in the near future should be modified and analyzed in the theoretical research. It could change our specification for the R&D and corresponding results. Thirdly, some restrictions on factor flow in the reality should be modified and analyzed in the theoretical research. Domestic capital flow restriction and its interaction with international capital flow in China (i.e. FDI and its relocation in regions and industries in China) should also be analyzed theoretically. Fourthly, since China's policies and business environment change vastly over time, some assumptions used here could be refined again in the future. Therefore this dynamic analysis only gives an indicator given the environment or conditions do not change so much (or so quickly). We hope readers to be mentioned this point especially. Finally, there is a policy suggestion. If there exists the loss for the specific region due to some sectors declining or the growth rate decreasing, for the incentive and sustainable development, the central government could think about the reasonable compensation for it.

Table 1: Domestic and Foreign Trade Ratios, 1992

(Percent of Provincial GDP, 25 Provinces)

Total Outflows/GDP	**70%**	
Domestic Outflows/GDP	49%	
Exports/GDP	20%	
		(Adjusted)
Total Inflows/GDP	**68%**	
Domestic Inflows/GDP	53%	(48%)
Imports/GDP	15%	(21%)

Table 2: Characteristics of Goods in Inter-provincial Trade

	Share of Total Domestic Outflows	Intra-Industry Trade Share of Total Trade	Percent Final Use	Domestic Outflows from 25 Provinces/ National Output
Chemicals, Rubber, Plastic	12.7%	70.3%	8.5%	34.1%
Machinery	9.8%	63.4%	43.9%	33.2%
Food Products	9.4%	67.5%	63.1%	31.1%
Agriculture	8.9%	56.2%	42.5%	11.3%
Textiles	8.7%	62.8%	7.2%	29.8%
Transport Machinery	8.4%	56.2%	36.3%	60.1%
Metallurgy	8.3%	55.4%	0.8%	31.4%
Building Materials	5.0%	49.0%	10.9%	28.2%

Electric Machinery	4.7%	39.8%	23.5%	39.2%
Electronics	3.6%	50.4%	41.8%	42.1%
Metal Products	3.2%	50.1%	12.7%	32.6%
Coal Mining	3.2%	33.5%	11.6%	52.0%
Garments	3.0%	50.4%	66.2%	27.0%
Paper, Toys, Handicrafts	2.9%	59.2%	16.9%	22.2%
Petroleum Refining	1.6%	36.7%	3.7%	19.5%
Petroleum	1.5%	35.2%	0.0%	27.9%
Other Industry	1.4%	44.0%	5.4%	40.6%
Mineral Mining	0.9%	37.0%	9.8%	19.5%
Ferrous Mining	0.8%	36.7%	0.0%	44.1%
Instruments	0.8%	61.8%	18.0%	46.8%
Coking & Coal Gas	0.5%	35.9%	35.2%	45.9%
Lumber & Furniture	0.4%	32.0%	28.3%	11.6%
Electricity	0.3%	15.4%	16.6%	3.9%

Notes: “Table 1” and “Table 2” are cited from Barry Naughton’s paper (1999).

Appendix

1. **Proof for Theorem 1:**

Substituting (12) and (13) into (9), we have the growth of output of knowledge:

$$(A-1) \qquad \frac{\dot{A}+\dot{A}^*}{A+A^*} = \delta H - \delta\psi\, p_A^{-\frac{1}{1-\alpha}} x^{\frac{1-\alpha-\beta}{1-\alpha}} (\theta^{\frac{2-\alpha}{1-\alpha}} + (1-\theta)^{\frac{2-\alpha}{1-\alpha}})],$$

From the definition of θ, (15), and (*A*-1), we can obtain the equation for the rate of change of the share of knowledge produced in the home region:

$$(A-2) \qquad \frac{\dot{\theta}}{\theta} = \frac{\dot{A}}{A} - \frac{\dot{\bar{A}}}{\bar{A}} = \delta(1-\theta)[H_y^* - H_y], \text{ where } \bar{A} = A + A^*.$$

Combining (12), (13), and (*A*-2), we obtain the following function:

$$(A-3) \qquad \frac{\dot{\theta}}{\theta} = \delta(1-\theta)\psi P_A^{-\frac{1}{1-\alpha}} x^{\frac{1-\alpha-\beta}{1-\alpha}} [(1-\theta)^{\frac{1}{1-\alpha}} - \theta^{\frac{1}{1-\alpha}}],$$

On the right-hand side of (*A*-3), the part outside the square brackets is positive. Therefore, we have the following results:

$$(i) \;\; \theta > \frac{1}{2}, \Rightarrow \dot{\theta} < 0; \quad (ii) \;\; \theta = \frac{1}{2}, \Rightarrow \dot{\theta} = 0; \quad (iii) \;\; \theta < \frac{1}{2}, \Rightarrow \dot{\theta} > 0.$$

These results are independent of all other parts of the dynamic system, x, P_A, θ, and the ratio of the aggregate C and the aggregate K are parameters in the dynamic system, as DL described in their paper (Devereux and Lapham, 1994, p.302), or other parameters in our models above. Since there are only corner solutions available for the case of θ = 1/2, therefore, the dynamic system cannot have a saddle point stability along SBGP path.

Q.E.D.

2. Proof for Theorem 2:

Proof: (i) Suppose θ<1/2.

Then, in the final feasible balanced growth equilibrium, from Theorem 1, we have θ = 0 and H_y = H. Therefore, from x = x(i)+x*(i) = x(i*)+x*(i*), the demand functions of x and x* derived from “equal wages” between two sectors in each country, and the corresponding equations in the foreign country, we can derive the new equation for the output of capital goods:

$$(A-4) \qquad x = p^{-\frac{1}{(\alpha+\beta)}}(1-\alpha-\beta)^{\frac{1}{(\alpha+\beta)}}[\frac{1}{2}(H_y^{\frac{\alpha}{\alpha+\beta}} + H_y^{*\frac{\alpha}{\alpha+\beta}})],$$

Then we have the function of r in term of x as follows:

$$(A-5) \quad r_{tech} = \frac{1}{2}[\phi^{\alpha(1-\alpha)}(1-\alpha-\beta)^{2(1-\alpha)}\chi^{-(\alpha+\beta)}]^{\frac{1}{\beta}} + \frac{1}{2}[(1-\alpha-\beta)^2 H^{\alpha}]^{\frac{1}{\alpha+\beta}}\chi^{-1}$$

where χ is the same composite variable as defined by DL: $\chi = xr^{(1-\alpha-\beta)/(\alpha+\beta)}$.

Since in the home country, A = 0, we pay more attention to the foreign country's situation. In the foreign country, the condition for balanced growth is that the growth rate of consumption is equal to that of new designs or new technology. Therefore, we get the following function of r in balanced growth:

$$(A-6) \qquad r = \sigma\delta[H - [\phi^{-(1-\alpha)}(1-\alpha-\beta)^{\frac{-2(1-\alpha-\beta)}{\alpha+\beta}}\chi]^{\frac{-(\alpha+\beta)}{\beta}} + \rho$$

The counterparts of (A-5) and (A-6) for the closed economy are given by:

$$(\text{A-5}') \qquad r_{tech} = [\phi^{\alpha(1-\alpha)}(1-\alpha-\beta)^{2(1-\alpha)}\chi^{-(\alpha+\beta)}]^{\frac{1}{\beta}},$$

$$(\text{A-6}') \qquad r = \sigma\delta[H - [\phi^{-(1-\alpha)}(1-\alpha-\beta)^{\frac{-2(1-\alpha-\beta)}{\alpha+\beta}}\chi]^{\frac{-(\alpha+\beta)}{\beta}}] + \rho$$

Now we compare (A-5) with (A-5'). Without loss of generality, suppose that (A-5) is greater than (A-5'). This would result in the following inequality (A-7).

$$(\text{A-7}) \quad \frac{1}{2}[(1-\alpha-\beta)^2 H^{\alpha}]^{\frac{1}{\alpha+\beta}}\chi^{-1} > \frac{1}{2}[\phi^{\alpha(1-\alpha)}(1-\alpha-\beta)^{2(1-\alpha)}\chi^{-(\alpha+\beta)}]^{\frac{1}{\beta}}$$

Then we get the reduced form as follows.

$$(A-8) \qquad [(1-\alpha-\beta)^{\frac{-(2-\alpha-\beta)}{\alpha+\beta}}] * [H^{\frac{\beta}{\alpha+\beta}}] > (\frac{\alpha}{\alpha+\beta})(\frac{1}{\delta})(\frac{1}{\chi}),$$

We have the assumptions that 0<α<1, 0<β<1, and 0<(1-α-β)<1; H is much greater than 1; and the technological coefficient δ is greater than 1. DL's composite variable $\chi= xr^{(1-\alpha-\beta)/(\alpha+\beta)}$ exceeds 1 since x and $r^{(1-\alpha-\beta)/(\alpha+\beta)}$ are greater than 1. With these assumptions the inequalities will hold since:

$$(A-9) \quad (1-\alpha-\beta)^{\frac{-(2-\alpha-\beta)}{\alpha+\beta}} > 1, \; H^{\frac{\beta}{\alpha+\beta}} > 1; \; (\frac{\alpha}{\alpha+\beta}) < 1, (\frac{1}{\delta}) < 1, (\frac{1}{\chi}) < 1.$$

Thus, these results are essentially the same as those of Devereux and Lapham (1994). That is, the balanced growth rate for Pattern 2 will be greater than that for each completely closed economy. The reason is that when (A-6) equals (A-6'), the r_{tech} in (A-5) is greater than the r_{tech} in (A-5'). We can use the DL method and show our result in Figure 1, where RR, R'R', GG represent the equations (A-5), (A-6') and (A-6), respectively. We can see that since the RR and R'R' are downward sloping hyperbolas in the graph, RR is to the left of R'R' everywhere, then for the same upward sloping graph of GG, the balanced values of r and χ for Pattern 2 are always bigger than those in each completely closed economy. Since the balanced growth rate g will rise with an increase in r, given other parameters in the equations for g, the balanced growth rate for Pattern 2 will be greater than that for each closed economy.

(ii) For the case of θ >1/2, the situation is symmetric to the case of θ <1/2 described above, so, the final results are exactly the same.

Q.E.D.

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