The Circulation and Sharing of High-Tech Talents and the Transnational Social Spaces Study Based on Stata Software

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Abstract. Stata is considered as an integrated and complete statistical software which offers its users to analyzing data, managing data and drawing professional diagrams. With the advent of information society, the advances and changes in science and technology are leading to growing requirements for innovation, and as a result, talents especially the high-tech talents have increasingly been contended by many countries. Nowadays, the flow of global high-tech talents has been changing from previous "Brain Drain", which represents a unidirectional and linear model from underdeveloped countries to developed countries or regions, to "Brain Circulation", a pattern owning bidirectional or multidirectional features. This paper will mainly use Stata software to conduct regression analysis with the aim of testing the correlation between brain drain and economic growth. In order to ensure the variable data utilized are relatively accurate, this paper has conducted stability test, multicollinearity test and correlation test. The findings are a growth in 1% in brain drain will result in 1.2% decrease in GDP per capita. It means the influence of Brain Drain is real and countries must pay adequate attention to. Combined the model of transnational social space, this paper theoretically expands the study on the influencing factors of Brain Circulation. It supplies a new perspective of migration system of talents and riches the study results of benefits-sharing mechanisms of global high-tech talents.

Keywords: Regression analysis · Brain Drain · Brain Circulation · high-tech talents · migration · sharing

1 Introduction

Under the influence of globalization, the geographical mobility of high-tech talents is shaping human capital markets and innovation activities worldwide. Building a globally competitive talent system plays a growing vital role in attracting and retaining high-tech talents. Since the 1960s, the phenomenon of "Brain Grain" has drawn the attention of numbers of politicians and economists [10]. "Brain Grain" was perceived as a severe problem for many developing countries, which signified the global migration of human resources capital, in especial the transfer of skilled persons from developing countries

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to North America and Western Europe [10]. Currently, the concept of "Brain Grain" is widely used to explain the one-way migration of talents from peripheral to central countries, combined with the resulting net loss of input countries and gains of output countries [12].

However, in the wake of globalization age, along with the impetus of the information technology revolution, talents, in especial the high-tech talents are cumulatively becoming the primary resources for national development. As a result of the frequented international migration of innovative and entrepreneurial talents, Brain Grain is increasingly replaced by Brain Circulation. More importantly, the paradigm of Brain Grain that based on the competition mechanism of gain and loss cannot emphasize the current complexity of migration of talents, particularly underestimate the importance of knowledge flow and diffusion.

By contrast, Brain Circulation stresses that the migration of talent is a complex and multidirectional process. Not merely the mobility of talents could benefit to receiving countries but the positive benefits like skills, human capital and knowledge gained by sending countries [25]. Returnees could transfer their knowledge and education received by other countries; returnees could maintain close social and economic ties with their home countries, which is likely to have a favorable impact on productivity growth, the creation of new businesses and enterprises, R&D and direct investment, and technological innovation.

Thus, this article will mainly explore the circulation and sharing of high-tech talents, putting transnational migration in perspective. Through applying Stata software to carry out regression analysis, the results show Brain drain exerts an important and negative influence on economic growth. Via constructing the transnational social spaces model, this article argues that the phenomenon of Brain Circulation arises from a combination of interactions among various behavior subjects of migration. Strengthening the flow and sharing of high-tech talents should be an integral part of national science, technology and economic policies. In doing so, this article will be divided into three parts. In the first part, the early migration of talents - Brain Drain will be analyzed. Followed by utilizing Stata to evaluate the relationship between Brain Drain and country's economy growth. The third part will present the transition of mobility of high-tech talents: Brain Circulation. The fourth part will examining the explanatory variables leading to the circulation of high-tech talents with the combination of applying transnational social spaces and the case study of Singapore. The final part will discuss the sharing of high-tech talents in the context of the Brain Circulation.

2 Early Migration of Talents: Brain Drain

Historically, the geographical flow of talents was not fresh to be discovered. It has been demonstrated that global geographical migration of early engineers and scientists was closely related with costs and benefits [6]. The notion of "Brain Drain" was used first in a report concerning the mobility of British engineers and scientists to the United States and Canada in the 1950s and early 1960s that written by the British Royal Society [8, 22]. In the coming decades, "Brain Drain" is more widely utilized to describe the phenomena of the one-way flow of skilled migrants from developing countries to developed countries or areas [2] (Fig. 1).

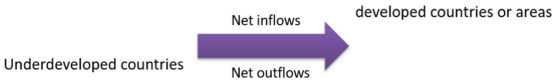

Fig. 1. Linear model - Brain drain

In the 1960s and 1970s, the debate with respect to "Brain Drain and Brain Gain" concentrates on losses for output countries or areas and by contrast, benefits for input countries. Brain drain was affected by unbalanced development of politics and economy in the global system [16, 20]. Arguments could be mainly summarized that skilled talents migrated to developed countries should attributed to the incomplete markets of sending countries which led to the incapacity to retain scientific elites; the solution is to introduce "Brain Drain Tax" (a kind of monetary compensation) between less developed countries (LDCs) and developed countries (DCs). LDCs should receive the income tax payments by DCs for compensating the losses of talents and other negative externalities brought to reduce welfare and growth [1].

In the 1990s and early 2000s, as it was stated by Giannoccolo's 2009 study that, a few scholars began to explore the issues on "Brain Drain" turning into "Brain Gain". They argued that although the possibilities of scientific elites' returning were low and which would cause confined incentives to gain education in a developing country, countries started to attach importance to education at hence, the educated proportion of remaining population would increase [8].

3 Research Design and Data Anaysis

Traditionally, governments treated high-tech talents leaving their home counties as weaken the potential of economy. In order to test the correlation between brain drain and economic growth, this paper will apply Stata software, combined with Munyniyi's 2015 study to solve this problem.

3.1 Stability Test

This paper will select the Augmented Dickey-Fuller test that put forward by Dickey and Fuller (1993) as the stability test [4]. This test checks whether a unit root is included in variables to consider. On the one hand, a null hypothesis is a unit root is contained in a variable if therefore used and tested. On the other hand, the alternative hypothesis is not contained in a variable, thus it was produced in a process of random walk and is stable.

The results of testing important variables using the Augmented Dickey-Fuller (ADF) test are showed below. In these tests, the results of lnTradeGDP and Infrate are not showed here but both stable. The other variables are showed below and not stable (Table 1).

Table 1. Stability test for lnGDPCap

Augmented Dickey-Fuller test for unit root			Number of obs = 41	
		Interpolated Dickey-Fuller		
	Test Statistic	1%critical Value	5%Critical Value	10%Critical Value
Z(t)	-l.364	-4.233	-3.536	-3.202

MacKinnon approximate p-value for Z(t) = 0.8710

D. lnGDPCap	Coef.	Std. Err.	t	P>l t l	[95% Conf.	Interval]
lnGDPCap						
L1.	-.1119389	.0820376	-1.36	0.181	-.2784841	.0546063
LD.	.3538244	.157412	2.25	0.031	.034261	.6733878
L2D.	.2186242	.1678666	1.30	0.201	-.1221631	.5594116
L3D.	-.2315615	.1677638	-1.38	0.176	-.5721402	.1090172
_trend	.0044086	.0029905	1.47	0.149	-.0016623	.0104796
_cons	.6027841	.4308451	1.40	0.171	-.271878	1.477446

Result 1: Time series data for GDP per capita is not stable due to the null hypothesis that it has a unit root cannot be rejected. To reduce the impacts of instability, the regression analysis will utilize a first order difference (Table 2).

Table 2. Stability test for lnGCapForm

Augmented Dickey-Fuller test for unit root			Number of obs = 41	
		Interpolated Dickey-Fuller		
	Test Statistic	1%critical Value	5%Critical Value	10%Critical Value
Z(t)	-l.001	-4.233	-3.536	-3.202

MacKinnon approximate p-value for Z(t) = 0.9440

D. lnGDPForm	Coef.	Std. Err.	t	P>l t l	[95% Conf.	Interval]
lnGDPForm						
L1.	-.1952825	.1950662	-1.00	0.324	-.591288	.2007231
LD.	-.1078081	.2099146	-0.51	0.611	-.5339574	.3183411
L2D.	-.2719157	.1843436	-1.48	0.149	-.6461532	.1023217
L3D.	-.2331702	.1727841	-l.35	0.186	-.5839406	.1176002
_trend	.0011557	.0013353	0.87	0.393	-.0015551	.0038666
_cons	.546243	.5873013	0.93	0.359	-.6460421	1.738528

Result 2: the outcomes of the test do not cause the null hypothesis to be rejected and can summarize that the series for lnGCapForm has a unit root and is unsteady (Table 3).

Table 3. Stability test for lnRemGDP

Dickey-Fuller test for unit root — Number of obs = 44

	Test Statistic	Interpolated Dickey-Fuller 1%critical Value	5%Critical Value	10%Critical Value
Z(t)	-l.545	-3.621	-2.947	-2.607

MacKinnon approximate p-value for Z(t) = 0.5112

Result 3: the results of the test do not lead to the null hypothesis to be rejected and can conclude that the series for InRemGDP has a unit root and is not stable (Table 4).

Table 4. Stability test for lnBdrain

Dickey-Fuller test for unit root — Number of obs = 44

	Test Statistic	Interpolated Dickey-Fuller 1%critical Value	5%Critical Value	10%Critical Value
Z(t)	-l.048	-3.621	-2.947	-2.607

MacKinnon approximate p-value for Z(t) = 0.7335

Result 4: The outcomes of ADF test shows that because brain drain has a unit root, the hypothesis that the time series data for brain drain cannot be rejected and thus, brain drain is not stable.

3.2 Multicollinearity Test

A multicollinearity test has been conducted with the purpose of ensuring the variable data utilized is noncollinear. The results are shown in Table 5.

Table 5. Collinearity test

Collinearity Diagnostics

Variable	VIF	SQRT VIF	Tolerance	R-Squared
lnGDPCap	2.29	1.51	0.4369	0.5631
lnTradeGDP	1 .81	1.34	0.5540	0.4460
lnGcapForm	1.72	1.31	0.5820	0.4180
lnRemGDP	4.75	2.18	0.2103	0.7897
Bdrain	4. 63	2.15	0.2160	0.7840
lnFDIGDP	1.15	1.07	0. 8680	0.1320
Infrate	1.31	1.15	0. 7620	0.2380
Mean vIF	2.52			

Result 5: If any independent variable meets VIF (βi) $>$ 10, the multicollinearity will be considered as high. In this model, the VIF for all variables utilized is less than 10. Although this model shows correlation between remittances (lnRemGDP) and brain drain (Bdrain) is low, the highest VIF is 4.75 and it can therefore summarize that multicollinearity is not an issue.

3.3 Test for Correlation

Result 6: Correlation analysis conducted in this table presented that among these variables, the correlation between lnGDPCap (economic development) and lnRemGDP (remittances) is positive (Table 6).

Table 6. Correlation test

. correlate lnGDPCap lnTradeGD lnGCapForm lnRemGDP Bdrain lnODAGNI lnfrate (obs=44)

	lnGDPCap	lnTrad∽P	lnGCap-m	lnRemGDP	Bdrain	lnODAGNI	lnfrate
lnGDPCap	1.0000						
lnTradeGDP	-0.3920	1.0000					
lnGCapForm	-0.0678	0.3056	1.0000				
lnRemGDP	0.5260	-0.3044	-0.5152	1.0000			
Bdrain	-0.5793	0.1897	0.4327	-0.8551	1.0000		
lnODAGNI	-0.1142	0.1473	0.1148	-0.0581	0.1663	1.0000	
lnfrate	-0.1091	0.3890	-0.1083	-0.0150	-0.0801	0.5483	1.0000

3.4 Regression Analysis and Results

The regression analysis was conducted via Stata. The outcome showed that Brain drain exerts an important and negative influence on economic growth. The outcomes can also be quantified as: a growth in 1% in brain drain would result in 1.2% decrease in GDP per capita. More importantly, it means the effect of Brain Drain is real and countries must pay adequate attention to (Table 7).

Table 7. Regression analysis result: Brain drain

Vector autoregression

Sample: 1971 - 2013		No. of obs	= 43
Log likelihood	= 38.04041	AIC	= -1.490252
FPE	= .0132164	HQIC	= -1.399627
Det(Sigma_ml)	= .0099797	SBIC	= -1.244503

Equation	Farms	RMSE	R-sq	chi2	P>chi2
lnGDPCap	6	.107694	0.9997	157071.3	0.0000

lnGDPCap	Coef •	Std. Err.	z	P>lz|	[95% Conf.	Interval]
lnGDPCap						
lnGDPCap						
L1.	.9537125	.0366959	25.99	0.000	.8817899	1.025635
lnTradeGDP	-.0815231	.1164607	-0.70	0.484	-.309782	.1467357
lnGCapForm	.2890534	.1838867	1.57	0.116	-.071358	.6494647
lnRemGDP	.0071145	.027941	0.25	0.799	-.0476488	.0618778
lnODAGNI	-.0959034	.0410963	-2.33	0.020	-.1764507	-.0153562
lnfrate	-.0023771	.0025314	-0.94	0.348	-.0073386	.0025844

4 The Pattern of Mobility of High-Tech Talents: Brain Circulation

With the globalization of research fields, the growing correlation of global scientific networks and the substantial development of contact channels, the return chances following geographical flow are growing rapidly. Meanwhile, the rising return of scientific elites to their host countries and continuous contact with diaspora has produced new research perspectives on talent migration. The one-way mobility of high-tech talents from underdeveloped countries to developed countries or regions has been replaced by a bidirectional or multidirectional flow model (triangle model), which is called "Brain Circulation" (Fig. 2).

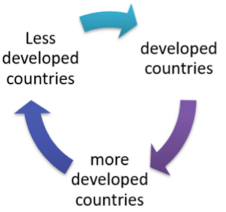

Fig. 2. Triangle model - Brain Circulation

The notion of "Brain Circulation" emphasizes not only the emigration of the high-tech talents from LDCs to DCs, but also their return to home countries or migration to a more developed country. Unlike the concept of "Brain Drain" which implies the negative impacts of skilled migration, in particular the losses for LDCs, "Brain Circulation" focuses on the benefits and chances generating to both LDCs and DCs [26]. For example, as it was claimed by India's former Prime Minister Manhoman Singh that, "Today we in India are experiencing the benefits of the reverse flow of income, investment and expertise from the global Indian diaspora. The problem of 'brain drain' has been converted into the opportunity of 'brain gain'" [11].

Indeed, in today's knowledge economy, the mobility of talents is the flow and dissemination of knowledge and technology. Frequent brain exchange enables both sending and receiving countries to benefit from the circulation of high-tech talents, and Brain Circulation provides new theoretical model and research method to analyze potential outcomes of labor mobility and its effects on persons, regions and countries.

5 Factors Affecting Brain Circulation

With the aim of crystallizing new comprehending of brain circulation procedure, it is necessary to examine the factors fostering brain circulation. Considering the migration of high-tech talents bonding sending and receiving countries, this article tries to introduce the algorithm of transnational social spaces model to illustrate the multinational phenomenon and practice of high-tech talents.

Singapore, is a city-island-country and its economic development has always been inextricably correlated with migration. Combined with the model of transnational social

spaces, it can be clearly seen how the behavior subjects, in particular government, civil society groups and transnational migrants resulting in the Brain Circulation and as a consequence, contributing to the success of Singapore.

5.1 Transnational Social Spaces Model

As it was put forward by Germany political scientist- Thomas Faist between 1998 and 2000 that, the concept of transnational social spaces is comprised of a number of factors which including "social and symbolic ties, positions in networks and organizations, and networks of organizations that span borders of multiple countries [5]. The theory of transnational social spaces regarded immigration system as a boundary-breaking process among sovereign nation-states. The newly formed transnational social spaces are defined by pentatonic relationships between rulers of immigration country, civil society groups in the immigration country, governments of emigration country, civil society organizations in the country of emigration, and transnational migrants [5]. With the interaction of various behavioral subjects around transnational migrants comes a presented mutual influence between different cultures and systems [3] (Fig. 3).

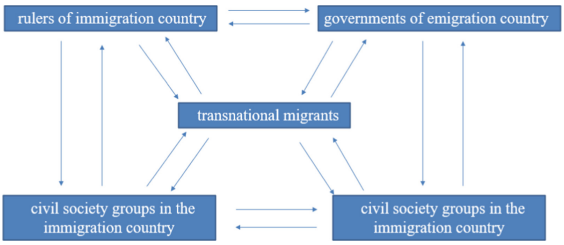

Fig. 3. Behavior subjects and multiple relationships of transnational social spaces

5.2 Government Dimension: Diversified Brain Gain Policies

It should be stressed that brain circulation is closely linked to brain gain policies, since they working towards the same purpose which tries to retrieve high-tech talents among overseas citizen group and seeks to cooperate with scientific elites regardless of their nationalities. As it was claimed in Mahroum's 2005 study, in today's intellectual world, brain circulation is promoted by varied brain gain policies [18]. High-tech talents could be attracted by the country which can supply comparatively better working conditions or other facilitates including tax discounts and eliminating language and other barriers.

In 1999, as it was described in "Manpower 21: vision of a talent capital", by the Singapore government that, tax rebates and other measures must be implemented to attract foreign talents [27]. Similarity, the government of Singapore has conducted a project named "Not Ordinarily Resident, NOR". This scheme targets at expatriates and they can enjoy the preferential paying income tax for five consecutive years [13]. Moreover, Singapore government can accomplish the issue of individual visa, assistance of land acquisition and quick loans in one month [27]. Amoud De Meyer, who is the dean of the

division of INSEAD, once argued that, the efficiency of Singapore government seems miraculous which could be rarely seen in other Asia countries [27].

In addition, the government of Singapore attaches great importance to the social integration of talents. In 2007, National Bureau of Population and Talent was founded with the aim of assisting immigrants to integrate into society and meanwhile, Singapore government transferred 10 million SGD (Singapore Dollar) to set up community integration funds. In 2009, National Integration Council was established by public and private sectors of Singapore which aimed at helping new immigrants to integrate into society and cultivate the sense of belonging [17]. All these policies have facilitated the talent attractiveness of Singapore and appealed large numbers of foreign high-tech talents to work in Singapore.

5.3 Civil Society Dimension: Open and Legal Labour Market

In the view of politics, despite the fact that the mobility of high-tech talents is associated with a country's human capital structure and bureaucratic governance system, the labour market plays a crucial role in migration decisions.

When summarizing the experience of attracting talents, the third prime minister of Singapore Lee Hsien Loong pointed out that, the prime reason should owe to equipped "software". Firstly, a society with the features of open, safe, constitutional and inclusive will make talents feel comfortable and prefer to settle with their families. Secondly, the labour market of Singapore uses English as working language which creates a compatible environment that enables talents worldwide to work together in Singapore. For instance, a Japanese enterprise can hire engineers from China, India and Malaysia, communicating in English. Thirdly, Singapore is promoting the expansion of biomedical research and nanotechnology market. It has formed an interactive virtuous cycle which attracts scientific elites and followed by high-tech talents attracting first-class scientific and technological talents [27].

5.4 Transnational Migrant Dimension: Development of Academic Career

Among the factors affecting the circulation of human resources, seeking chances of better career development should be the core element. The mobility of talents can not only promote the flow and diffusion of knowledge, but also be considered as a self-development process, particularly for those research-active and wage-premium high-tech talents [9].

Compared with local talents without country migration experience, highly-skilled talents with migration experience tends more likely to re-migrate. The reason is not merely loose connection between high-skilled talents and destination of migration, but job opportunities supplied by different countries [14].

According to Franzoni et al.'s 2012 research that, for high-tech talents, the purpose of migration is primarily to obtain prestige of foreign institution, opportunity to improve future career prospects, cooperate with top research team, better research facilities and working environment and other benefits such as life quality and academic freedom. These are conductive to enhance the capacity of personal career development and competitiveness in the labor market [7] (Fig. 4).

Fig. 4. Factors affecting emigration for high-tech talents (Adapted from (Franzoni et al., 2012: 1250–1253)) [7]

Examples showed some high-tech talents who came from United States determine to immigrate to Singapore instead of South Korea, China (like Hong Kong, Beijing, Shanghai) as a consequence of low environmental pollution, not required complicated formalities or household registration system, and equipped top-class health care and education standards [27]. These should owe to the talent strategy which is regarded as the core of national policies and leads scientific elites from developed countries to be willing to migrate to Singapore.

6 Sharing of High-Tech Talents in Brain Circulation

6.1 Human Capital vs Social Capital

From a conventional view, the flow of talents treated labour mainly as human capital, or the comprehensive performance of education, skills, and experience of individuals. Whereas, in the model of Brain Circulation, transnational labors are considered as social capital, or the ability to produce manifested in the network connections among governments, societies and individuals. Social capital offers intangible but equally significant outcomes, for example strengthening trust and collaboration and forming benefit-sharing, and easier to obtain latest market information and access to innovations in reform [21].

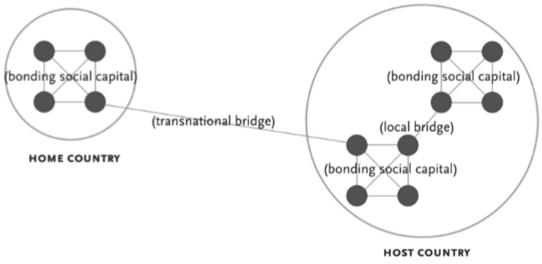

Fig. 5. Transnational social capital (Adapted from (Shin and Choi, 2015)) [23]

The traditional human capital flow regards high-tech talents as a zero-sum game where receiving country gains a net inflow of human capital from sending country, commonly brings about the phenomena of "Brain Drain" for the sending countries and "Brain Gain" for the receiving countries.

In the newly research approach (Fig. 5), yet, Brain Circulation creates brain ties and win-win, positive-sum situation between sending and receiving countries. Unlike conventional linkages bonding members of congenerous groups or linkages bonding members of different social groups in local area, transnational social capital links members of diverse countries [24].

In the perspective of transnational social capital, Brain Drain provides a chance for brain ties in spite of the possible risk of lose situation before gain faced by country. Therefore, if Brain Drain can be transformed into Brain Circulation, it will be beneficial for the social and economic development of home countries.

6.2 Brain Circulation and Diaspora Effect

In the context of Brain Circulation, culture identity is facilitating diaspora and other overseas scientific elites to return to their home countries with the objective of work and establish connections. The diaspora act as global "search network", bonding international and domestic markets and playing an active role in the transfer of knowledge, technology and capital. For example, the Indian-born employees working in IT enterprises of United States (like Silicon Valley in California) have offered suggestions on technical knowledge and connections of markets that promote the export of India's software services and foreign investments in India's IT sector [15].

Furthermore, diaspora can be regarded as the major means of attracting foreign direct investments and increasing foreign exchange earnings. Remittance, as a stable foreign exchange income, can also treated as a way to establish connection with international capital market. Examples like in the last few decades, the diaspora from India and Israel have financed $11 billion and $25 billion separately [15].

7 Conclusions

This paper has carried out regression analysis via Stata. The results shows that Brain drain exerts an important and negative influence on economic growth. Therefore, countries should pay more attention on Brain Drain.

Moreover, the circulation of high-tech talents is of great theoretical and practical significance, which required countries to treat attracting high-tech talents as national long-term and priority development strategies. To be a destination country for high-end human capital flows marks the modernization of higher education and innovative strength.

Last but not least, from the point of view of government, on the one hand, developing and emerging countries need a portion of high-tech talents to work in developed countries or the most technologically advanced countries. These scientific elites can transfer advanced technology and experience to their home countries. The stay of talents in host countries, on the other hand, can guide enterprises of home countries to go abroad and

promote cultural dissemination. For China, there is a requirement for converting the emphasize on "the return of individuals" into "the return of talents"; it will more easily to attract overseas Chinese to carry out project cooperation and technical exchange with the motherland.

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