Cross-regional trade effects: A comparative analysis of total factor productivity growth in Hong Kong and Shanghai

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Abstract

Hong Kong and Shanghai are both regions that have experienced extraordinarily high levels of growth over the past few decades. Neoclassical growth theory predicts that output growth is driven by continual increases in total factor productivity (TFP). This theory is consistent with the output to TFP ratio in Shanghai but not in Hong Kong. To understand why this difference exists in two economies of similar size and culture, this paper uses orthogonalized impulse response functions to test the connection between growth drivers across the two economies. The results show a significant response of Shanghai's TFP to shocks to Hong Kong exports to China, aggregate trade, TFP, and output. This suggests that Shanghai has received a spillover of knowledge from Hong Kong, which has contributed to high levels of TFP and, subsequently, output growth.

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1 Introduction

In 2009, Shanghai's GDP surpassed Hong Kong's, reaching 218.28 billion USD. Hong Kong and Shanghai are both regions that have recently experienced high levels of economic growth, although Hong Kong's peak years preceded Shanghai's. As China transformed from a closed, centrally-planned economy to an open, market-based growth machine, Hong Kong helped to play the middleman between Mainland China and the rest of the world.

Hong Kong and China have an interesting political, historical, and economic relationship. Although China's economy is much larger than Hong Kong's economy, Hong Kong has played an important role in China's development by helping to catalyze its connection to the rest of the world in the post-Mao era. Shanghai has an almost identically sized economy and represents one of the most prosperous regions of China. It is therefore an effective region to use as a case study to evaluate the economic significance of the relationship between Hong Kong and China. In this paper, I aim to identify and articulate the economic connection between Hong Kong and Shanghai.

Hong Kong and Shanghai have both experienced extremely high levels of growth over the past few decades, in some years reaching up to a recorded 30% gross domestic product (GDP) growth in one year. Neoclassical growth theory cites total factor productivity (TFP) as the primary driver of this growth, with the ratio of GDP to TFP growth falling around 1.5 in the steady state. The United States, for example, has averaged 3.45% GDP growth and 1.09% TFP growth, which is a 3.16 ratio.[1] Hong Kong and Shanghai's GDP to TFP ratios are very different from each other. In Shanghai, GDP growth averages 14.3% and TFP averages 9.97%, for a ratio of 1.43, as neoclassical theory predicts it to be. In contrast, Hong Kong GDP growth averages 8.3% annually while TFP averages 1.58% annually, creating a GDP to TFP ratio of 5.25. High levels of GDP growth given low levels of TFP growth are an anomaly to neoclassical growth theory. Although the regions are of similar sized economies, evidently the structure of their growth is different. This paper looks for a connection

[1] All averages are taken from 1983-2008 due to data constraints. US GDP according to NIPA tables, TFP calculated by John Fernald (Federal Reserve Bank of San Francisco)

between Shanghai and Hong Kong's TFP to understand why they are at such different levels of growth.

My hypothesis is that Shanghai receives a spillover of knowledge from Hong Kong through trade and information flows that adds to TFP and conversely fuels their GDP growth. This is consistent with the history as Hong Kong has been integrated into the global economy longer and thus acquired the knowledge and necessary institutional and capital structure much earlier than Shanghai. Once Shanghai started to grow and develop, it was able to capture some of this knowledge from Hong Kong to help maintain high levels of GDP growth.

To test this hypothesis, I used orthogonalized impulse response functions (OIRF). These OIRFs test for responses in Shanghai and Hong Kong TFP to shocks on other macroeconomic indicators in the opposite economy, including GDP, exports, and aggregate trade. The data is consistent with the theory, as Shanghai TFP had significant response to impulse shocks to Hong Kong GDP, TFP, exports to China, and aggregate trade. The relationship is not present in the opposite direction, meaning Hong Kong TFP does not respond to shocks to any Shanghai variables. This supports my hypothesis that Shanghai receives a spillover of knowledge from Hong Kong that boost to TFP growth and, consequently, GDP growth.

As Shanghai continues to grow in terms of both TFP and GDP, neoclassical theory predicts that there will be a convergence between the two economies in terms of GDP per capita. Generally, this convergence is driven by economies having the same levels of capital accumulation and TFP. In this case, Shanghai needs to catch up to Hong Kong in terms of knowledge. At this point, growth would be expected to slow in Shanghai's economy.

Sections 2 through 5 of the paper set up the historical, theoretical and economic background necessary for understanding the result. Section 2 outlines the historical background of each economy and the relationship between the two. This is intended to provide a context for understanding the data trends, the timeline of government policy, and the intrinsic connection between the two economies. This section also outlines previous studies that serve as a framework for this research. Section 3 then describes the data

sources and the TFP construction methodology. A TFP measure is constructed using a Cobb-Douglas production function, reported data, and estimated capital according to the perpetual inventory method. Section 4 presents the basic economic facts and correlations of business cycle measures within and across the two economies, which suggest that Hong Kong leads Shanghai growth. Section 5 decomposes the basics of Solow growth theory. This theory provides a backdrop of steady-state capital accumulation for understanding the contrast between the growth drivers in the two economies.

Sections 6 and 7 discuss the findings of the research and their implications. Section 6 presents the methodology and results. To analyze the connections between Shanghai and Hong Kong, I employ basic vector auto regressions (VAR), orthogonalized impulse response functions (OIRF), and forecast error variance decompositions (FEVD). The results find a unidirectional relationship in which Shanghai TFP responds positively to shocks to several Hong Kong macroeconomic factors. Section 7 discusses theoretical explanations for these results, establishing the theory that Shanghai as a poorer and less developed region received spillover knowledge effects from its interactions with Hong Kong. I also outline areas for further research.

2 Background

In this section I describe the historical relationship between the two economies and discuss previous studies that are related to this research.

2.1 Historical background

The relationship between Hong Kong and Shanghai has revolved around trade since China started to reform its trade system in the late 1970s. Before China's reform and opening up, Hong Kong thrived on the growth of its manufacturing sector, fueled by inexpensive labor. With the development of manufacturing in Mainland China and the increasing real estate costs in Hong Kong, this advantage was lost. Given Hong Kong's proximity to this new

manufacturing hub, Hong Kong developed many supporting service industries revolving around trade and financial services which linked its economy to the Mainland.

Figure 1: Map of China

Hong Kong's proximity to the Mainland and its easy ocean access to Shanghai fostered a close economic partnership between the two economies after China's reform and opening up policies in 1979.

Hong Kong quickly established itself as a re-export center for many Mainland products since it already had large ports in place. Since China has developed their domestic services, the need for Hong Kong to play an intermediary role declined. A relatively high demand for Hong Kong's services remains. In addition to playing a middleman role in the re-exporting process, Hong Kong also evolved as a middleman in offshore trading. The market for these services continued to develop, through the handover of Hong Kong to Mainland China in 1997 (Sung 2006). Hong Kong is also linked to the Mainland's economy through foreign direct investment (FDI). While China's financial system remained highly underdeveloped into the 1990s due to lack of infrastructure and high levels of centralization, Hong Kong had established foreign financial institutions, which were able to facilitate large investments into China (Jao 2006).

Shanghai has been at the forefront of China's reforms in economic structure and policies and currently operates as a major financial and trade hub of Asia. Even in the pre-reform

era, Shanghai served as the primary foreign trade hub of China. Subsequently, Shanghai was a forerunner of foreign trade and investment following Deng Xiapoing's reform policies in 1979. It has since emerged as a major catalyst of growth by connecting the Mainland to the rest of the world.

Shanghai rivals Hong Kong in terms of industry and skill. Tian (1996) argues that Shangahi holds a comparative advantage in several areas, not simply in the classic cheap unskilled labor sector. With a relatively educated population and extensive infrastructure in place, Shanghai experienced some of the biggest growth booms in all of China, recording a record 30.5% growth rate in 1993.[2]

The massive expansion of Shanghai as a domestic port and the rapid improvement to infrastructure and domestic services have both created serious competition for Hong Kong. In response to the lower demand for re-exporting services, Hong Kong has restructured to be more involved as the middleman of offshore trading. Hong Kong's financial role has also faced strong competition from a rapidly growing Shanghai financial center.

The two economies are intrinsically linked through trade, investment, state-owned institutions, and multi-national corporations. Hong Kong and Shanghai have always been strong trade partners. In 1991, for example, Hong Kong received 18.7% of Shanghai's total exports. Foreign direct investment flowing from Hong Kong to Shanghai also connects the two. As Shanghai has attained development rivaling that of Hong Kong, its export-market structure has diversified and Hong Kong's involvement as an entrepôt center has accordingly decreased (Tian 1996, 87-93). Currently the two economies remain strongly linked through trade of goods and services, financial investments, and corporate interests.

2.2 Related studies

In the context of traditional growth analysis models, many economists have taken an interest in the case of East Asia given that the growth patterns exhibited in many of these

[2] See section 3.1 for details on data sources

economies contradict fundamental principles of economic growth models. The basic idea behind growth analysis is to decompose what drives rapid growth and also what ensures long-run growth. With the empirical cases of many East Asian countries, the neoclassical Solow growth model does not always provide adequate explanation.

Young (1992) performed a comparison case study on Hong Kong and Singapore to analyze differences in growth structures. Though these two are similar in terms of economic structure, several endogenous growth factors including education, government policy, investment rates, and TFP contributions to growth are dissimilar. His paper centered around the fact that although Hong Kong's TFP growth from 1966-1991 averaged 2.3% while Singapore's was only 0.2%, they have both experienced high GDP growth rates. Postulating that Singapore's strong growth will only continue in the short-run whereas Hong Kong's pattern of growth will persist over a longer period of time, he concludes that the neoclassical growth model correctly identifies that acquisition of knowledge is more important for long-term growth than the accumulation of factors of production, such as capital.

With updated data from the 1990s, Imai (2001) reevaluates Young's Hong Kong thesis. While Hong Kong maintained high growth throughout the 1980s due to its seamless structural transformation from the manufacturing industry to trade and other service industries, this growth does not persist through the 1990s. Imai cites domestic exports as the driver of growth, thus as manufactured exports declined, growth stagnated. Using a Solow model, Imai also finds considerable TFP growth during 1980s, but slowed TFP growth and a lack of capital deepening in the 1990s. This slowed TFP growth subsequently lead to a decrease in GDP growth. It appears that growth post-1980s was not driven by productivity effect but instead by an improvement in the terms of trade. This type of growth provides high short-run gains but projects weaker long-run growth prospects than Young originally predicted.

Liao and Liu (2009) challenge the common claim that growth in many East Asian economies is export-led. Focusing on the relationship between exports and TFP to understand causality between trade and growth, they claim exports do not necessarily

cause growth because it is not a unidirectional relationship. In other words, productivity growth can cause economic growth which in turn stimulates exports. They find a diverse set of results across nations implying different outward orientation strategies, each at different stages of development. In the case of Hong Kong and China, however, TFP growth leads export growth.

This paper builds off of these studies and uses Hong Kong and Shanghai for a case study on growth models. Hong Kong and China have an interesting political, historical, and economic relationship. Because China's economy dwarfs Hong Kong's economy, it is difficult to ascertain the role if any that Hong Kong has played in China's development. Shanghai, however, has an almost identically sized economy and represents one of the most prosperous regions of China. In this paper, I aim to identify and articulate the economic relationship between Hong Kong and Shanghai.

3 Data and TFP construction

This section outlines the sources each data series used in the paper, and also describes how TFP data was constructed using the perpetual inventory method and growth accounting principles.

3.1 Data sources

Data on Hong Kong's GDP, employment, investment structure, and trade is available publicly from the Hong Kong Census Bureau. Employment is measured simply as total number of employees. Investment is reported as gross capital fixed formation, which is used as a basis for estimating the capital stock. All series are available from 1961, with the exception of exports to China which begins in 1972 and employment which begins in 1982.

Shanghai has the status of a province of China and thus has its specific data published as part of the Chinese provincial statistical yearbooks, which is accessible through chinadataonline.org. Data is available for GDP, employment, investment and trade from 1953 onward. Jun et al (2007) estimated capital stock series for given years in Shanghai

starting in 1952 using the perpetual inventory method with specific adjustments for each Chinese province.

Hong Kong data and Shanghai data is recorded in Hong Kong dollars (HKD) and Chinese renminbi (RMB) respectively. I converted the data to US dollars using the 2008 pegged-value exchange rates of 7.75 HKD per USD and 6.83 RMB per USD. All analysis uses first differenced logs of this data.

3.2 TFP construction

The estimate of the TFP growth rate in each economy uses a Cobb-Douglas production function with inputs of TFP (z), capital stock (K), and labor (N). We assume a standard value of 1/3 for α.

Total number of employees is used as a measure for labor. This data is available from 1951 for Shanghai and from 1982 for Hong Kong. Capital stock data for Shanghai is taken from Jun et al (2007), but no data is reported on capital stock for Hong Kong. Using gross capital formation data for Hong Kong, I constructed a measure of capital stock using the perpetual inventory method:

$$K_{t+1} = I_t + (1-\delta)K_t$$

With this data on capital and assuming a 5% depreciation rate and $K_o = I_o/\delta$, the growth rate is calculated according to the following equation:

$$\Delta \ln K_{t+1} = I_t/K_t - \delta$$

TFP growth is then backed out according to the production function:

$$\Delta \ln z = \Delta \ln y - \alpha \Delta \ln K + (1-\alpha)\Delta \ln N$$

4 Basic economic facts and correlations

This section goes over all of the basic elements of Hong Kong and Shanghai's economy that are pertinent to this paper including business cycle facts and GDP and TFP growth rates. It also looks at dynamic correlations across the two economies to look for preliminary evidence for a connection between them.

4.1 Business cycle facts

In order to preliminarily look for links between Hong Kong and Shanghai's economies, I looked at some basic business cycle facts in each economy and tested correlations both within each economy and across the two.

Hong Kong's GDP components all show a high level of correlation with GDP, with the exception of employment (see table 1). Within Shanghai's economy, investment, TFP, and labor productivity are all highly correlated with GDP, while consumption's correlation is low. Moreover, correlations between both exports and imports and GDP in Shanghai are nearly acyclical, whereas in Hong Kong they are equally strong. According to these inner-region correlations, the similarities in the two economies occur in correlations between GDP and investment, TFP, and labor productivity.

Table 1: Business cycle fluctuations and correlations with GDP

	Shanghai		**Hong Kong**	
	Std deviation	*Correlation with output*	*Std deviation*	*Correlation with output*
Y	0.1166	1.0000	0.0770	1.0000
C	0.0895	0.4835	0.0711	0.8661
I	0.2585	0.7948	0.1632	0.7965
N	0.0490	0.2004	0.0163	0.4406
IM	4.4958	0.0502	0.0793	0.7311
EX	0.2269	0.2071	0.0954	0.7573
Y/N	0.1171	0.9122	0.0654	0.9748
TFP	0.1199	0.9478	0.0592	0.9564

All statistics are first-differenced logged values of annual data where Y = GDP, C = consumption, I = investment, N = employment, IM = imports, EX = exports, Y/N = labor productivity, and TFP = total factor productivity

Hong Kong and Shanghai's GDP levels have converged in recent years, which makes sense in light of Shanghai's more recent growth and development. Fluctuations in growth rate have been similar since the 1990s although Shanghai has consistently had more positive growth than Hong Kong (see Figure 2). The two regions also have similar levels of aggregate trade, though Shanghai's trade is larger relative to GDP. After 1990, the growth rates of aggregate trade follow similar patterns of volatility in both Shanghai and Hong Kong although Shanghai is always above Hong Kong (see Figure 3). TFP growth rates have diverged since the 1990s, as Shanghai saw a large spike and Hong Kong began a downward trend. Starting in the 2000s, however, fluctuations in TFP growth rates have mirrored each other (see Figure 4).

Figure 2: GDP growth rate comparison

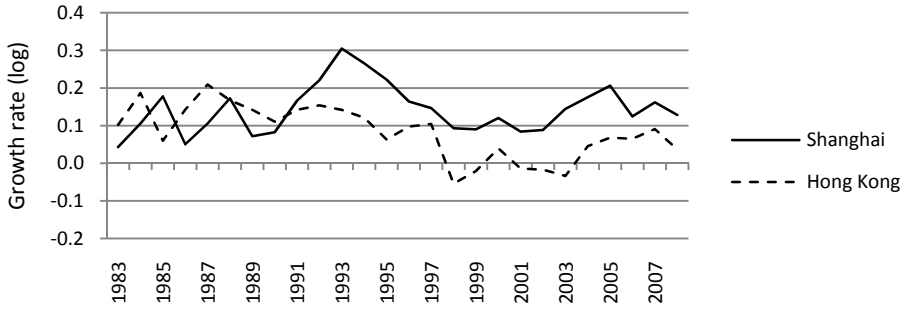


Figure 3: Aggregate trade growth rate comparison

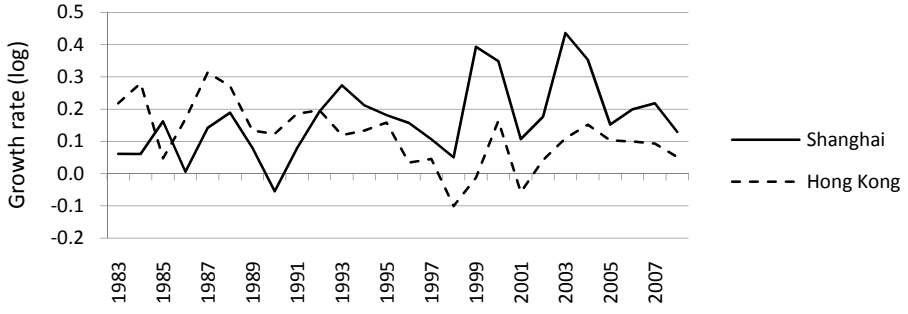
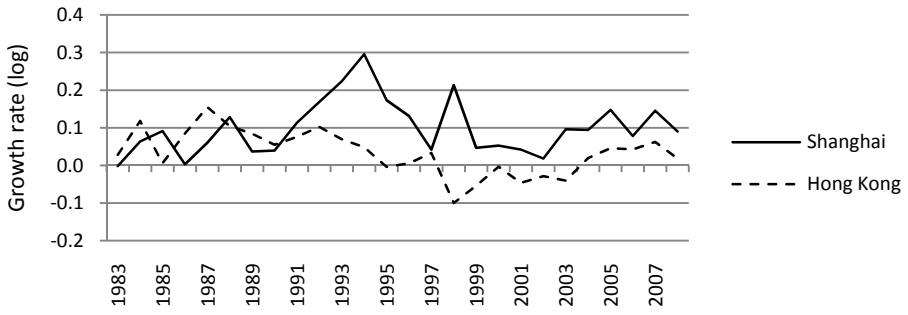


Figure 4: TFP growth rate comparison



Across all three statistics, Shanghai surpassed Hong Kong in terms of growth rates in the early 1990s. Since this over taking, the graphs show that although Shanghai has maintained higher rates of growth, the two economies follow similar trends. These similar trends begin in the early 1990s in GDP and aggregate trade growth, but not until the 2000s in the case of TFP growth.

4.2 GDP and TFP growth comparison

When looking at the growth rates of TFP in comparison to those of GDP in Hong Kong and Shanghai respectively (table 2), it is evident that something different is happening in each economy.

Table 2: GDP and TFP growth rate comparison

	Shanghai		**Hong Kong**	
	GDP	TFP	GDP	TFP
1985-1989	11.56%	6.40%	14.42%	8.67%
1990-1994	20.81%	16.82%	13.39%	7.02%
1995-1999	14.32%	12.14%	3.80%	-2.38%
2000-2004	12.27%	6.04%	0.39%	-2.00%
2005-2008	15.52%	11.53%	6.50%	4.21%
1983-2008	14.29%	9.97%	8.26%	1.58%

GDP and TFP growth in 4 year intervals from 1985-2008, based on annual data and calculated TFP

In Hong Kong, GDP growth averages 8.3% annually while TFP averages 1.58% annually. In Shanghai, GDP growth is also very high averaging 14.3% and TFP averaging 9.97%. The ratio between TFP and GDP growth in Shanghai follows a typical growth accounting model, which cites GDP growth rates at approximately 1.5 times the TFP growth rates. Conversely, in Hong Kong, this model does not hold. Evidently, something else is fueling Hong Kong's economy, while Shanghai drives its high levels of GDP growth through the accumulation of technical knowledge.

4.3 Dynamic correlations

The contemporaneous correlation (see table 3) between Hong Kong's output and Shanghai's TFP is weak. With Shanghai's TFP leading 5 years, the correlation is much stronger and still positive. This indicates that an increase in Hong Kong GDP today would have a positive effect on Shanghai TFP 5 years in the future. With the opposite, the correlation is strongly negative. In other words, Hong Kong GDP 5 years in the future has a negative effect on current Shanghai TFP. This fits with the hypothesis that Hong Kong's growth is helping Shanghai's TFP growth.

Table 3: Dynamic correlations between Hong Kong output and Shanghai TFP

Time	Correlation
Contemporaneous	0.045766
Shanghai TFP leads by 5 years	0.231454
Hong Kong GDP leads by 5 years	-0.612469

5 Neoclassical growth theory

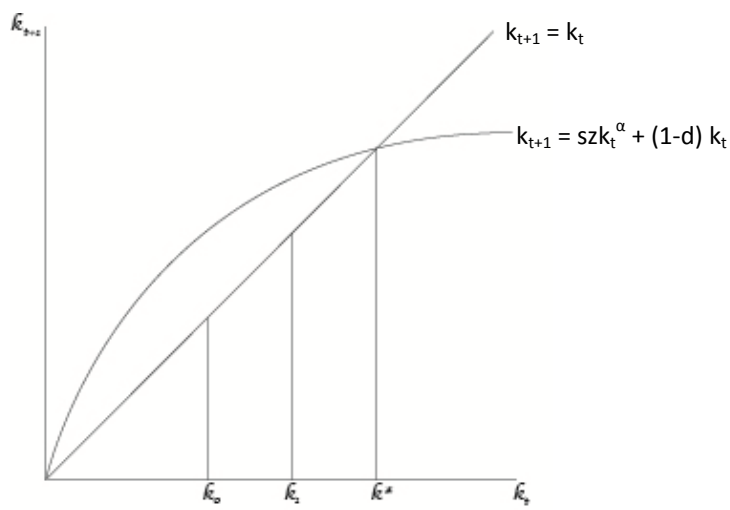
Neoclassical growth theory explains growth through a combination of changes in capital accumulation, savings rates, population, and technological progress. The central

component of this theory is the per worker capital accumulation function, where k = capital, s = savings, z = TFP and d = depreciation:[3]

$$k_{t+1} = szk_t^{\alpha} + (1\text{-}d)\ k_t$$

Figure 5 is a graphical representation of this equation. The ray represents $k_{t+1} = k_t$ and the curve is the per worker capital accumulation function stated above. The intersection point of these two curves is the steady-state, an optimal equilibrium that is stable. At the given levels of savings, TFP and depreciation, once capital per worker reaches this level, it will not change. In other words, capital accumulation does not explain long-run growth.

Figure 5: Basic Solow growth model

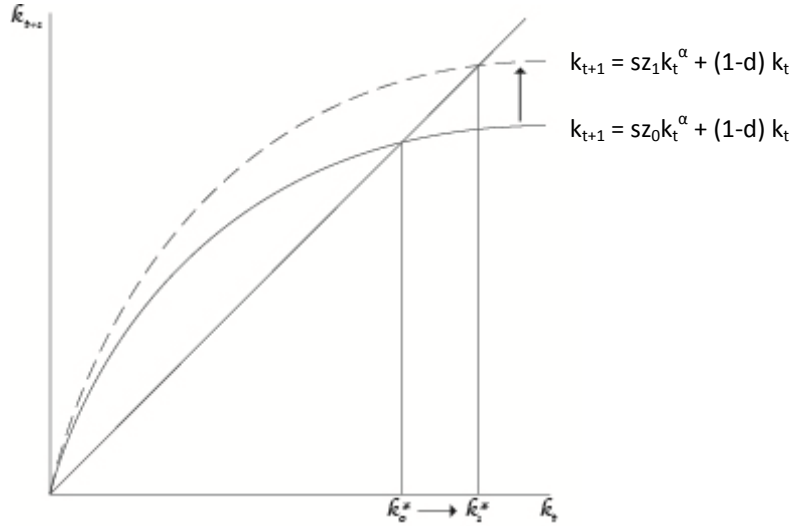


Capital accumulation occurs until steady-state is reached. The steady-state is the intersection point at k*. Capital accumulation will converge at this point and remain constant unless the savings rate (s) or TFP level (z) changes.

Although there is no growth in capital per worker in the steady-state, the aggregate level of capital should be growing at a rate equal to population growth. Moreover, changes to the savings rate and TFP will cause the steady-state to shift and subsequently increase or decrease per worker accumulation capital. Figure 6 illustrates the effect of an increase in total factor productivity on the steady-state.

[3] Uses a per worker production function of $y_t = zk_t^{\alpha}$, standard value for α is 1/3

Figure 6: Effect of increase in TFP on the steady-state



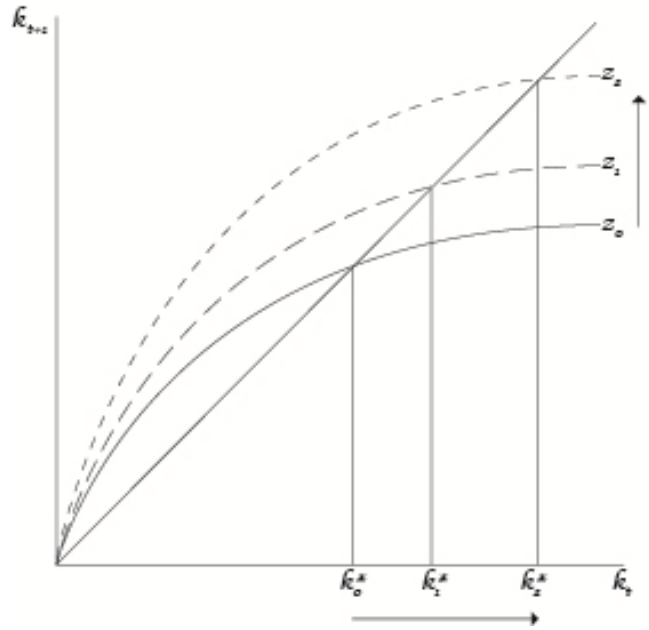
This economy is in a steady-state at k_0*. Following an increase in TFP from z_o to z_1, the per worker capital accumulation function increased to the dotted line and capital level will converge to the new steady-state, k_1*.

In Figure 6, TFP increases thus shifting the production function up and increasing the steady-state from k_0* to k_1*. This will cause an increase in capital per worker. These changes to TFP will also affect output per worker in the long-run (Solow 1956, 1957).[4]

In the context of the Solow growth model, the growth scenarios in Hong Kong and Shanghai appear to be quite different. The Solow model states that changes in TFP are the only way to fuel long-run growth. In Shanghai, the numbers make sense with this model. From 1983 to 2008, Shanghai's GDP grew an average of 14.29% per year while TFP grew an average of 9.97% per year. As TFP increases, the production function shifts upward shifting the steady-state to higher levels of capital accumulation (see Figure 7). This pattern of growth fuels high levels of GDP growth after an extended period of time.

[4] Solow defines total factor productivity or "technical change" as any kind of shift to the production function including increased productivity, improvements to technology, changes in educational levels.

Figure 7: Solow model of Shanghai growth



When TFP is equal to z_0, the Shanghai economy is in a steady-state at k_0*. As TFP increases from z_o to z_1 to z_2, the production function shifts upward representing higher levels of technological possibilities. The per worker capital level will eventually converge to the new steady-state, k_2*.

Hong Kong's growth does not fit into the Solow model. In Hong Kong, GDP growth averaged 8.3% annually while TFP averaged 1.58% annually. The increases in TFP are too small to account for such high levels of GDP growth. Possibly, Hong Kong has not reached its steady-state and thus is still increasing capital per worker to increase growth (similar to Figure 5). Hong Kong's economy is clearly, however, not able to accumulate technical knowledge or change at levels comparable to Shanghai.

My hypothesis is that Shanghai receives a spillover of knowledge from Hong Kong through trade and information flows that adds to TFP and conversely fuels their GDP growth. This is consistent with the history as Hong Kong developed much earlier than Shanghai. In other words, Hong Kong was integrated into the global economy years before Shanghai was through China's opening up and reform policies. Since the reform, Hong Kong and Shanghai have become increasingly economically tied and a transfer of knowledge has occurred between the two, which has helped Shanghai to reach such high levels of growth. To

evaluate this hypothesis, I test the relationship between the economies using basic vector auto regressive models and orthogonalized impulse response functions.

6 OIRF methodology and results

6.1 VAR and OIRF methodology

This paper uses basic vector auto regressive (VAR) models to analyze the relationships between the economies of Hong Kong and Shanghai. To help with the interpretation of these regressions, orthogonalized impulse response functions (OIRFs) and forecast error variance decompositions (FEVDs) are also analyzed.

Basic VAR models allow a variable to be affected by current and past information of a series. For this paper, I am particularly interested in how growth indicators, i.e. GDP and TFP, in each economy are affected by shocks to their counterparts in the other economy and to other exogenous variables. For example, one VAR regression tested the effect of current and past Hong Kong output growth and past Shanghai TFP growth on current Shanghai TFP.

To understand the implications of these VAR regressions, I looked at the orthogonalized impulse response results. OIRFs are used to measure reactions within a dynamic system to an external change. The IRF is simply the standard deviation of the error term (σ_u). This standard deviation represents an external shock or unexpected change in openness. For this particular case, the set of regressions is as follows, where SHz is Shanghai TFP and HKy is Hong Kong output:

$$SHz_t = a_o + a_1 SHz_{t-1} + a_2 HKy_{t-1} + a_3 HKy_t + e_t$$
$$HKy_t = b_o + b_1 HKy_{t-1} + b_2 SHz_{t-1} + b_3 SHz_t + u_t$$

This system of equations measures the chain reaction of Shanghai TFP (the response variable) to shocks to Hong Kong's output (the impulse variable). I necessarily assume that

$b_3 = 0$, meaning changes to current Shanghai TFP will not contemporaneously affect Hong Kong output. This ensures that the error terms do not have indirect contemporaneous effects on the variables.

The FEVDs measure the percentage contribution of the impulse variable shocks to the response variable. This is calculated by measuring the squared sum of one particular OIRF relative to the squared sum of all the OIRFs, as shown in the below equation where h = time horizon and j = shock:

$$\frac{\sum_{j=0}^{h}\left(IRF_j^1\right)^2}{\sum_{j=0}^{h}\left(IRF_j^1\right)^2+\sum_{j=0}^{h}\left(IRF_j^2\right)^2}$$

This methodology is used throughout the paper to analyze the response of Shanghai TFP to Hong Kong output, TFP, aggregate trade, and exports shocks.

6.2 OIRF results

For the OIRF analysis, I looked into several macroeconomic growth indicators including: GDP, TFP, aggregate trade, and exports. The OIRFs indicate statistically insignificant response from Hong Kong TFP to shocks on Shanghai's indicators. The significant results are all present in the opposite direction, rooted in a response from Shanghai's TFP to shocks on Hong Kong's indicators.

Table 4: Summary of OIRF results

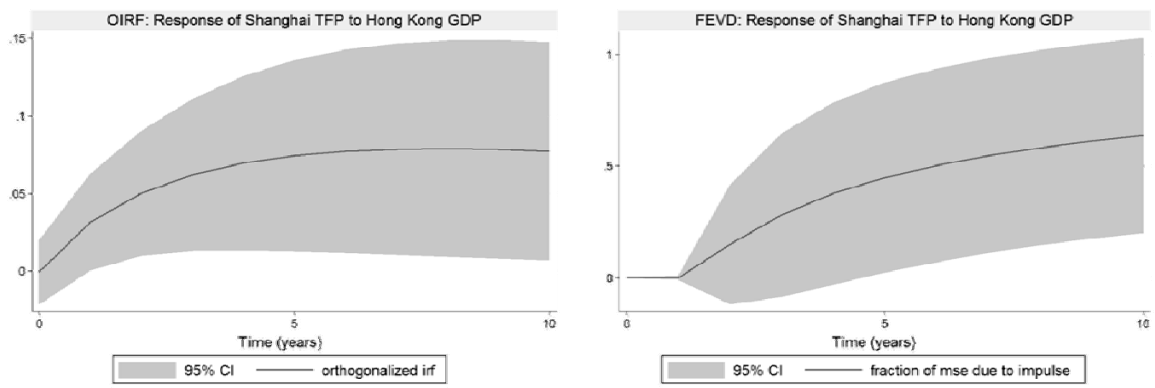
		Impulse Variable, Hong Kong indicators			
		GDP	TFP	Exports to China	Aggregate Trade
Response variable	Shanghai TFP	✓	✓	✓	✓
		Impulse Variable, Shanghai indicators			
		GDP	TFP	Exports	Aggregate Trade
	Hong Kong TFP	x	x	x	x

✓ indicates statistically significant OIRF, x indicates statistically insignificant OIRF

The OIRF in Figure 8a tests the relationship between Hong Kong's GDP and Shanghai's TFP, which is represented by the following equation, where the impulse is the standard deviation of u_t:[5]

$$SHz_t = a_o + a_1SHz_{t-1} + a_2HKy_{t-1} + a_3HKy_t + e_t$$
$$HKy_t = b_o + b_1HKy_{t-1} + b_2SHz_{t-1} + b_3SHz_t + u_t$$

Figure 8: Response of Shanghai TFP to Hong Kong GDP



(a) OIRF (b) FEVD

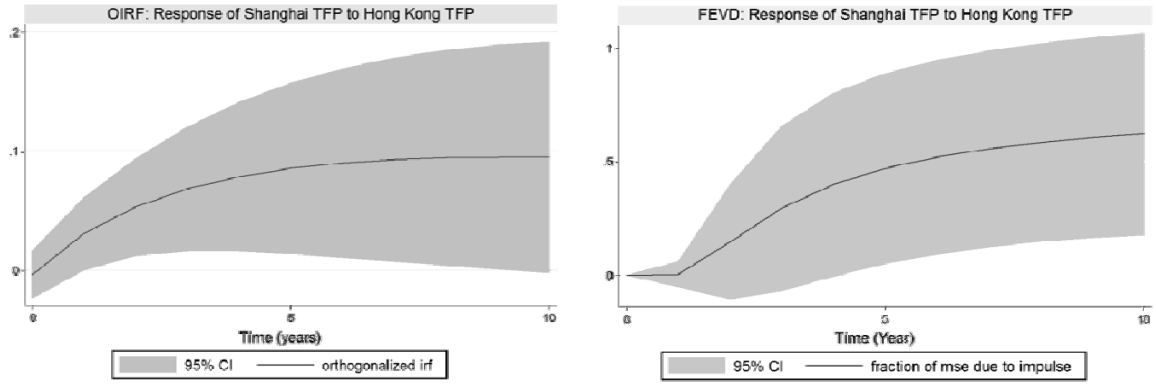
Figure 8a & b– Basic VAR regression, 2 lags, grey area represents 95% confidence interval. FEVD is zero until year 1.

The next OIRF in Figure 9a tests the relationship between Hong Kong's TFP and Shanghai's TFP. These results are similar to those in the previous figure, though the initial impulse response is slightly higher in response to Hong Kong TFP. This test is represented by the following equation, where the impulse is the standard deviation of u_t:

$$SHz_t = a_o + a_1SHz_{t-1} + a_2HKz_{t-1} + a_3HKz_t + e_t$$
$$HKz_t = b_o + b_1HKz_{t-1} + b_2SHz_{t-1} + b_3SHz_t + u_t$$

[5] For all impulse response functions b_3 is constrained to 0 to fix for correlated residuals

Figure 9: Response of Shanghai TFP to Hong Kong TFP



(a) OIRF (b) FEVD

Figure 9a & b - Basic VAR regression, 2 lags, grey area represents 95% confidence interval. FEVD is zero until year 1.

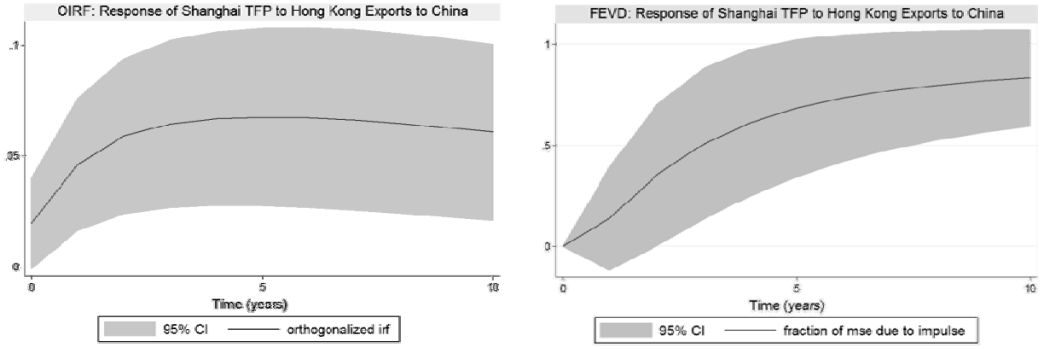
In the case of both of these regressions, there is an initial spike in the impulse response function within the first year, after which the response tapers off. The FEVD graphs in both cases, however, show that the shock is only responsible for a significant portion of this change after the first year.

The OIRF in Figure 10a tests the relationship between Hong Kong's exports to China and Shanghai's TFP, which is represented by the following equation, where the impulse is the standard deviation of u_t:

$$SHz_t = a_o + a_1SHz_{t-1} + a_2HKex_{t-1} + a_3HKex_t + e_t$$

$$HKex_t = b_o + b_1HKex_{t-1} + b_2SHz_{t-1} + b_3SHz_t + u_t$$

Figure 10: Response of Shanghai TFP to Hong Kong Exports to China



(a) OIRF (b) FEVD

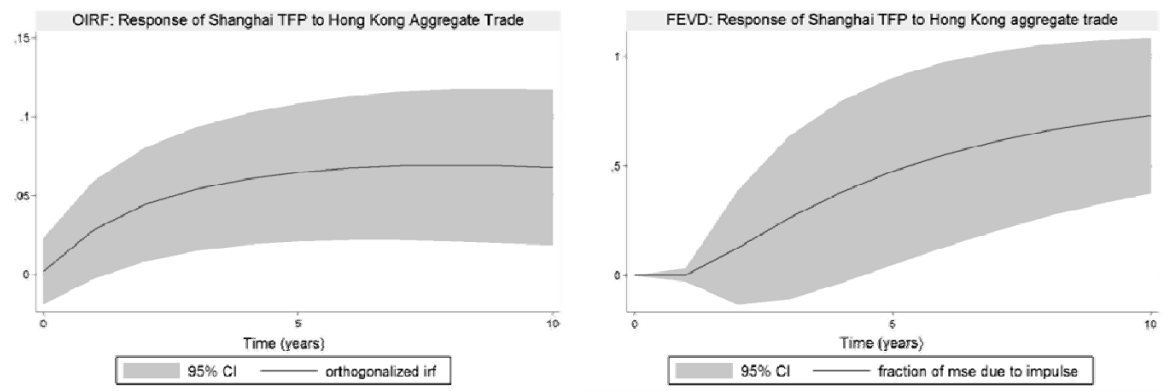
Figure 10a & b– Basic VAR regression, 2 lags, grey area represents 95% confidence interval. FEVD is 0.1363 in year 1.

This OIRF has a higher immediate effect than the previous two figures. The FEVD is also different in that there is an immediate spike in the graph. In the first year, the shock to Hong Kong exports to China is responsible for 13.63% of the increase seen in the OIRF.

The final statistically significant OIRF, Figure 11a, tests the relationship between Hong Kong's aggregate trade level and Shanghai's TFP, which is represented by the following equation, where the impulse is the standard deviation of u_t:

$$SHz_t = a_o + a_1SHz_{t-1} + a_2HKt_{t-1} + a_3HKt_t + e_t$$
$$HKt_t = b_o + b_1HKt_{t-1} + b_2SHz_{t-1} + b_3SHz_t + u_t$$

Figure 11: Response of Shanghai TFP to Hong Kong Aggregate Trade



(a) OIRF (b) FEVD

Figure 11a & b– Basic VAR regression, 2 lags, grey area represents 95% confidence interval.

This OIRF shows Shanghai TFP giving a similar response to the shock to Hong Kong aggregate trade as in figures 4&5. It makes sense that Figure 6 would be the most positive with the strongest FEVD, since exports to China are a more specific measure of the connection between the two economies than any of the other factors.

7 Discussion

The OIRFs show that there is a response of Shanghai TFP to four Hong Kong macroeconomic factors, with no such repsonse in the opposite direction. This is consistent

with my hypothesis that Shanghai receives a spillover of knowledge from Hong Kong through trade and information flows that adds to TFP and conversely fuels their GDP growth. This section discusses the theory behind why this relationship is occuring, the implications of this research, and further areas of research that could be explored.

7.1 Theoretical explanations

There are a couple of important things to note about the results of these OIRFs. First, while Shanghai's TFP has a statistically significant, positive response to shocks to four Hong Kong macroeconomic indicators, the relationship does not exist in the other direction. In other words, Hong Kong TFP does not receive positive benefits from shocks to Shanghai exports, aggregate trade, GDP or TFP (see Appendix, figure A1). Second, Shanghai TFP has the most positive, instantaneous response to a shock to Hong Kong exports to China.

The theoretical idea behind this draws on the background of the two economies. Due to China's closed economic policies and Hong Kong's contrastingly open and free economic atmosphere, Hong Kong was able to develop at rapid rates at least 20 years prior to Shanghai. Thus, once China reversed its policies in the late 1970s, Hong Kong was geographically and economically poised to establish trade relationships with the coastal cities of the Mainland. Shanghai was particularly important in these early stages because it's exports accounted for up to 23% of all of Mainland China's exports in the 1980s (Tian 1996, 89).

During the 1980s, Hong Kong was outgrowing Shanghai in terms of TFP and GDP growth. As is shown in table 5, however, in the past decade, Shanghai's growth rates dwarf those of Hong Kong.

Table 5: Comparison of growth rates in 1980s and 2000s

	Shanghai		**Hong Kong**	
	TFP	GDP	TFP	GDP
1983-1990	5.26%	10.10%	7.93%	14.00%
2000-2008	8.48%	13.71%	0.76%	3.11%

The idea behind these interactions, as evidenced by the OIRFs, is that Shanghai was able to capitalize on its relationship with Hong Kong. After the reform and opening policies were implemented, an influx of knowledge flowed into Shanghai from Hong Kong especially in the form of traded goods and services. As the trade flows between the two regions increased, these interactions caused a spillover of knowledge. Shanghai accumulated knowledge from Hong Kong, a richer and more developed region, which accounts for a portion of Shanghai's TFP growth.

In mathematical terms, a model to represent these interactions is below, where a_1 represents the effect that trade between Hong Kong and Shanghai has on the relative values of their TFP :

$$z_t^{SH} - z_t^{HK} = -a_1 trade_{t-1}$$

While I was able to find data on Hong Kong exports to China, I was unable to find complete data on exact trade flows specifically between Hong Kong and Shanghai.[6] Thus, due to data limitations, I am unable to estimate this coefficient. What I would expect to see is as trade increases between the two economies, Shanghai would continue to gain knowledge from Hong Kong and thus their TFP would relatively increase, decreasing the gap between the two.

It is important to note, that while Shanghai was able to catch up and surpass Hong Kong in terms of GDP and TFP growth rates, it only passed Hong Kong's gross value of GDP in 2009. With over twice the population of Hong Kong, however, Shanghai still maintains a relatively low level of GDP/capita. Still, these positive advantages of trade have contributed to rapid increases to the standard of living in Shanghai, which should also be expected to have spillover effects on neighboring regions in China.

Neoclassical growth theory predicts that with the same levels of capital and TFP, two economies will converge to the same steady state. In the case of Shanghai and Hong Kong,

[6]China data center online publishes Shanghai Statistical Yearbooks for select years from 1995 onwards. There are reported values for Shanghai exports to Hong Kong for some of these years, although the data does not triangulate properly as they are recorded through different mechanisms (i.e., value of foreign trade exports vs. total export trade volume through customs)

this model predicts that Shanghai will eventually catch up to Hong Kong in terms of GDP per capita, once it learns everything it needs to know. Usually, this convergence occurs through capital accumulation, but in this case it is driven by increases to TFP.

TFP incorporates everything that contributes to output growth excluding capital and labor. This includes knowledge, technology, innovation, efficiency, institutions, legal systems, etc. Over the past few decades, Shanghai has been developing in many of these areas and has already experienced large increases in its standard of living. Since Hong Kong was an open economy long before Shanghai, Shanghai has been able to learn from Hong Kong from its trade connection with Hong Kong and to maintain high TFP growth. As Shanghai continues to acquire more knowledge and increase its level of TFP, its output will subsequently grow further driving the convergence between the two economies.

7.2 Areas for further research

This case study finds that a less developed region, Shanghai, benefits from trade with a more developed region, Hong Kong, through a positive externality of knowledge that spills over. If clearer data on trade specifically between Shanghai and Hong Kong exists, it would be interesting to solve for the coefficient in the trade model proposed in the previous section. Moreover, I would expect the OIRF of a response of Shanghai TFP to shocks to trade specifically between Hong Kong and Shanghai to have a stronger response than any of the significant OIRFs tested in this paper. I would also expect Hong Kong to have a similar relationship with the Guangzhou and Shenzhen, as they are directly across the mainland from Hong Kong Island. Growth in this region is even more recent than growth in Shanghai. Data constraints, however, restrict this hypothesis from being tested.[7] Finally, although Taiwan developed later than Hong Kong, it is also considered a Special Autonomous Region by China and might have similar links with Shanghai and other major coastal Chinese cities.

[7] Data is available for Guangdong province as a whole, but not specifically for the growth within these cities.

Perhaps the case of Hong Kong and Shanghai is isolated due to specific geographical and historical circumstances. In order to test for broader implications of this theory, I would be interested in examining whether this type of knowledge spillover in the form of TFP growth is evident between other economies on a larger scale, such as between Mexico and the United States, and between those that are farther apart, such as between England and some of its former colonies.

8 Conclusion

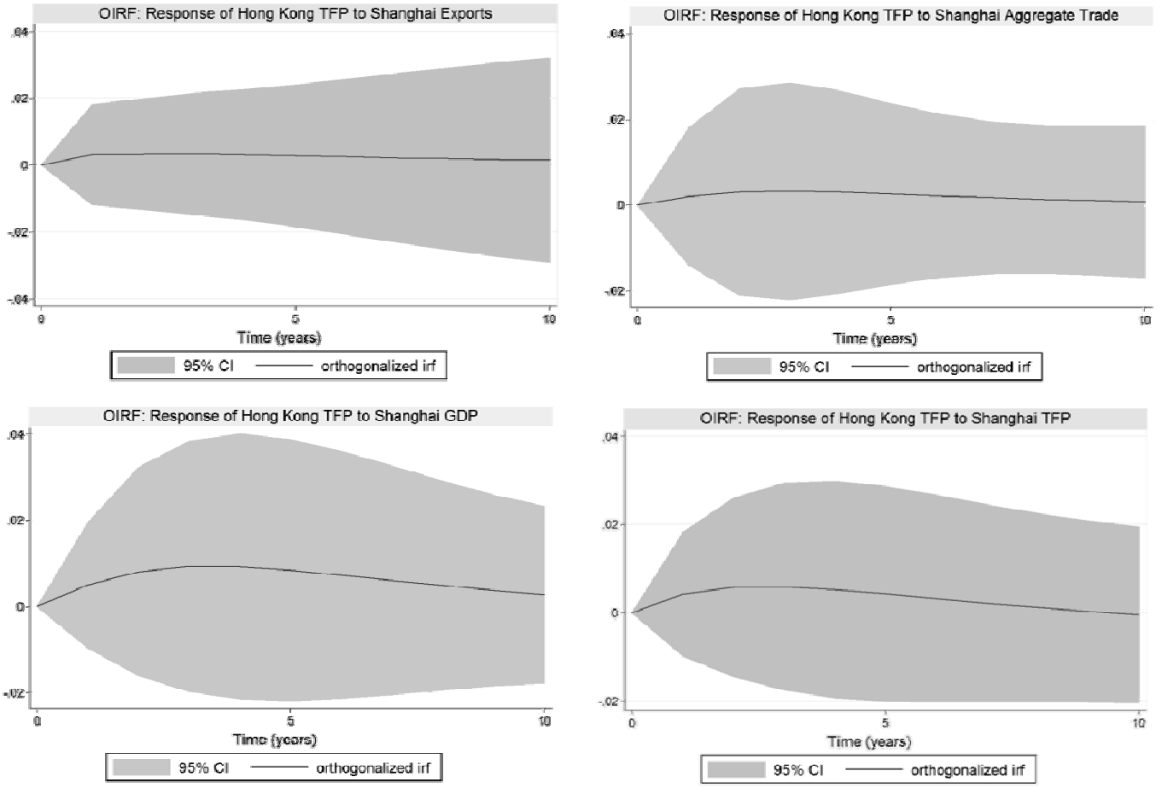
Hong Kong is considered to be the freest economy in the world according to the Index of Economic Freedom. It has been a gateway from Asia to the West for decades and received influence and knowledge from the West much sooner than most Asian nations. China, a now booming economy, shut itself off from the rest of the world for the bulk of the twentieth century. Since it opened up its borders to trade in the late 1970s, the coastal regions of China have experienced record-setting levels of growth, especially in Shanghai.

This paper finds that Shanghai GDP growth is driven by TFP growth, while Hong Kong's growth is not. Shocks to levels of aggregate trade, GDP, TFP, and exports to China in Hong Kong all result in increases to Shanghai's TFP. In other words, Shanghai is benefiting from its trade and interactions with Hong Kong. There is a knowledge spillover from a developed economy to an economy that has just recently developed.

From a broader, theoretical perspective, this connection between Hong Kong and Shanghai suggests that when a developed region trades with a less-developed region there is an externality of knowledge spillover that helps to catalyze development within the less-developed region. This additional benefit to trade is one to keep in mind when evaluating the benefits of trade liberalization around the world.

Appendix

Figure A1: OIRF response of Hong Kong TFP to shocks to Shanghai exports, aggregate trade, GDP, and TFP



In contrast to the same tests in the opposite direction, none of these OIRFs are statistically significant. OIRF proof that relationship is unilateral from Hong Kong to Shanghai. Black line is the OIRF; gray shaded area represents 95% confidence interval.

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