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Information and Communication Technology-Enabled Modern Services Export Performances of Asian Economies

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Advancements in information and communication technology (ICT) have expanded the possibilities for trade in modern services. Many emerging and developed Asian economies are increasingly participating in these new trade activities. This study examines the export performances of emerging and developed Asian economies in selected modern services—computer and information, business and professional, and telecommunications—using a stochastic frontier gravity model. Estimation results show that the performances of emerging economies in South Asia and the Association of Southeast Asian Nations (ASEAN), in terms of realization of export potential, are considerably weaker than those of developed economies in North America and Europe. The results show that the number of graduates and the quality of ICT infrastructure in emerging economies are among the key factors in realizing services export potential. These findings suggest that emerging economies need to remove behind-the-border constraints and adopt advanced technologies to catch up with high-performing developed economies.

Keywords: Asia, Europe, North America, service exports, stochastic frontier gravity model
JEL codes: C24, F14

I. Introduction

Over the past 2 decades, technological developments, the liberalization of the services trade, and the rising share of services in most economies have resulted in the increasing globalization of services. In terms of world gross domestic product (GDP), the share of services increased from 59% in 1985 to 71% in 2011, underlying the tremendous scope for trade in services. Also, unprecedented advancements in information and communication technology (ICT) have made it possible to provide many services across borders without the physical movement of persons. In the

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literature, modern services are broadly defined as commercial services excluding the traditional services of transport and travel (Ghani 2010, Ghani and Anand 2009). ICT advances have revolutionized trade possibilities in modern services, especially telecommunications, computer and information, banking, insurance, and other business services. Given these developments, modern services exports are growing more rapidly than traditional services exports, reaching $2.3 trillion in 2011. In 2011, the share of modern services was 54% of the total services trade, an increase from 35% in 1990. Overall, the modern services trade is growing even faster than the goods trade. Since 1990, the modern services trade has increased nearly eightfold compared with a fivefold increase in the goods trade.[1]

The economies of South Asia, East Asia, and the Association of Southeast Asian Nations (ASEAN) are increasingly participating in the growing market for modern services exports. South's Asia share of global exports of computer and information services increased from 10% in 2000 to over 25% in 2011. However, there are differences in export growth across economies and within economies across different modern services exports. For example, in 2000–2011, India and Pakistan experienced significant growth in the export of business and professional services (BPS), while there was slow growth in these exports from Indonesia and Malaysia over the same period. Meanwhile, Malaysia has invested heavily in infrastructure, including the creation of an entire city, Cyberjaya, to promote ICT-related production and exports.[2]

To what extent have economies involved in the export of computer and information services and BPS reached their potential? How are economies in South Asia and ASEAN performing with respect to their peers and the developed world in terms of utilization of export potential in modern services? This analysis is important for emerging economies that are experiencing an increase in services exports as a share of their overall economic growth. The efficient utilization of an economy's export potential increases its exports and overall economic growth. The analysis of export potential also has useful policy implications for export growth: economies with lower rates of utilization of their potential bilateral services exports first need to remove behind-the-border constraints before adopting the advanced technologies and trade practices of high-performing economies. Furthermore, economies that are close to their potential should exert more effort in research and development (R&D) and the development of new technologies to shift their potential frontiers.

Developments in modern services have attracted much research, particularly on the issue of job losses in the developed world due to the outsourcing of services to emerging economies. To our knowledge, no study has analyzed the modern services export potential of emerging economies, although there are a limited number of studies on the estimation of gravity models for modern services. Most studies

[1] Figures are based on data from the World Bank (2012).

[2] Cyberjaya is an ICT-themed city in Malaysia with state-of-the-art infrastructure and ICT systems.

use aggregate levels of the services trade and have less coverage of exports from emerging economies. Grünfeld and Moxnes (2003), Mirza and Nicoletti (2004), and Kimura and Lee (2006) find gravity estimates only for aggregate services and goods using an Organisation for Economic Co-operation and Development (OECD) dataset for up to 20 OECD reporting economies. Another study by Head, Mayer, and Ries (2009) calculates the gravity estimates for other commercial services, ICT, and miscellaneous business services using Eurostat data for the period 1992–2006.[3] However, bilateral coverage of data for most economies before 2000 is small, which may influence estimations.

Services are different from goods in terms of restrictions on trade. Due to the specific nature of various services and the different modes of supply, domestic regulations are the primary restrictions on services trade (World Trade Organization [WTO] 2012). Specific discriminatory regulations in services sectors can have negative effects on trade flows. Licensing requirements, quotas on foreign providers, and cumbersome procedures are some of the regulations that can reduce potential trade in professional services. One of the limitations with aggregate services analysis is that we cannot analyze the impact of sector-specific services trade restrictions on services exports. For example, Grünfeld and Moxnes (2003) use the Services Trade Restrictiveness Index (STRI) developed by Findlay and Warren (2000), but their analysis was inherently biased because these STRIs only cover 35% of total services. Kimura and Lee (2006), using 1999–2000 data for 10 OECD economies, apply the Economic Freedom of the World Index as a crude proxy for barriers to trade in services.[4] A recent study by Nordas (2008) uses sector-specific STRIs and estimates a gravity type model at a disaggregated level for computer and information services and business services. On the other hand, Head, Mayer, and Ries (2009) do not include services trade restrictions in their gravity model specification. With regard to the impacts of outsourcing on the labor markets of those economies demanding the services provided through outsourcing, most of the theoretical models discussed in Francois and Hoekman (2010) have predicted positive gains for high-skilled wages in the United States (US) market and a marginal impact on low-skilled jobs.

The characteristics of services vary between categories. For example, the nature of BPS is very different from that of transport services. Therefore, aggregate analysis used in earlier studies, with due acknowledgement, is of limited use for policy makers. The quality and coverage of services data has improved only recently. In earlier studies, the limited number of observations at the disaggregated level might have compromised the estimations. Therefore, the current study is expected to contribute in three ways. First, it provides a systematic analysis of the performances of emerging economies in modern services exports in terms of utilization of their

[3]Other commercial services are calculated by subtracting transport, travel, and government services from total services.

[4]These economies report services trade data for most of their partner economies.

potential, using the stochastic gravity frontier approach. Second, it uses a larger and more complete dataset than those used in earlier studies. Finally, it explains the potential and determinants of modern services exports at a disaggregated level.

Developments in ICT have made it possible for emerging economies to exploit their comparative advantage in some modern services. The driving force for this comparative advantage is the large pool of semiskilled and skilled graduates in emerging economies who can deliver their services across borders using advanced communication technologies. Trade in services can take different forms. Services can be an intermediate or a final product, and services can be delivered through a foreign presence or via cross-border trade using communication networks. This study focuses on modern services that are delivered largely through cross-border trade; outsourcing has contributed to the increase in these exports from emerging economies (Bhagwati, Panagariya, and Srinivasan 2004). Feenstra (2008) notes that developing economies also outsource services to developed economies for high value-added and high-end tasks. For example, the software industries in India and Pakistan import the services of US professionals for tasks for which domestic expertise is scarce. In this context, tight restrictions on other modes of supply drive businesses to pursue cross-border transactions to the point that the possibility of measured flows being higher than they would be otherwise may not be completely ruled out. However, it is not an issue in this paper because what is discussed here concerns the export potential of the modern services trade of selected economies for given levels of determinants including technical knowledge and capacity. The objective of this study is to gauge, for those given determinants of the modern services trade, maximum possible trade and the gap between such a maximum and actual trade. Thus, in a way, this is a demand-side analysis.

The remainder of the paper is structured as follows. The next two sections provide information about the size and structure of the services trade and details on the data availability of bilateral services trade flows. Section IV briefly discusses the analytical framework for the estimation of the services trade. The discussion concerns the application of the stochastic frontier approach to gravity modeling along with details of explanatory variables included in the empirical model. The results of the maximum likelihood estimation and export performances are also discussed in this section. A final section presents the overall conclusions of this study.

II. Trends in Services Trade

The services sector has been the most dynamic segment of the global economy over the last decade. In the domestic economy, services' share of the GDP of middle- and high-income economies has been rising. The sector accounted for 72% of global GDP growth in 2001–2011. In the external economy, services have been dominating the landscape of both trade and foreign direct investment. Most foreign

direct investment in the last decade has been in the services sector as growth of the modern services trade has surpassed growth in the goods trade. At the aggregate level, total world trade in commercial services increased from $0.82 trillion in 1990 to $4.3 trillion in 2011, representing growth of about 424%. The modern services trade is the main source of this growth with a current volume of over $2.3 trillion, which covers more than 54% of the total global services trade. High-income economies remain the dominant players in commercial services with a share of about 80% of world trade in 2011, down from about 87% in 1990.

Modern services exports also showed smaller contractions compared with goods exports during the global financial crisis in 2007–2009. In order to understand Asia's sustained services export growth rates and rapid recovery from the global financial crisis, it is important to analyze the sectoral composition of the contraction in global trade and final demand during this period (Bems, Johnson, and Yi 2010; Borchert and Mattoo 2009). First, contraction in world final demand was far less for services than for durables during the period Q1 2008–Q2 2009: the US and 15 members of the European Union (EU) experienced a contraction of only 1%–3% in demand for services against a 20%–30% fall in demand for durables (Bems, Johnson, and Yi 2010). One of the primary reasons for this relatively smaller drop in services is that most modern services, such as back office services, are unrelated to the volume of goods production. Therefore, even if goods production declines, the demand for these services will be less affected. Second, the negligible fall in final demand for services is also reflected in a smaller contraction in the services trade compared with the goods trade.

The outsourcing of services to developing economies is of concern to some policy makers in the developed world, though both the theoretical and empirical studies reviewed by Francois and Hoekman (2010) show that the impact of services outsourcing on OECD labor markets has been insignificant. Only about 8% of world exports of modern services are from lower-middle-income economies. It is only with respect to ICT-enabled services that lower-middle-income economies have a larger share of the world total (about 23%), most of which is contributed by India. Lower-middle-income economies, excluding India, have not experienced a significant change in their share of world modern services exports, showing that the benefits of the increase in modern services exports is still limited to a few emerging economies.[5]

Telecommunications services, computer and information services, and BPS collectively account for more than 60% of modern services exports. These are the fastest growing segments of the services trade among emerging economies engaged in outsourcing activities. The increase in ICT-enabled services and BPS exports from these economies has been largely due to the increasing trend of outsourcing activities. Total world estimates for the trade in computer and information services exceeded

[5]Figures in this paragraph are based on data reported in the World Bank's *World Development Indicators* and the International Monetary Fund's Balance of Payments Statistics, and cover cross-border services trade.

$287 billion in 2011, increasing from $18.5 billion in 1997 on an average annual growth rate of about 24%. India, Ireland, the United Kingdom (UK), Germany, the US, the Netherlands, Sweden, Canada, and the People's Republic of China (PRC) are among the top exporters of computer and information services. Currently, in the world market for BPS exports, the US, the UK, Germany, and Japan are the main players. In South Asia and ASEAN, India, the PRC, and the Philippines are the lead BPS exporters.

While other emerging economies can exploit their potential and benefit from expanding markets, the emerging economies of Asia (excluding India) have not experienced a significant change in their global share of modern services exports, demonstrating that the benefits of growth in the modern services trade have thus far been limited to a few Asian economies.[6] In terms of world share of modern services exports, East Asia and ASEAN did not show an increase in their respective shares between 2000 and 2010 (Table 1). During this period, the growth rate in modern services exports from South Asia was almost double the growth rate of these exports from East Asia, ASEAN, and the global average (Table 2). South Asia increased its world share of modern services exports from 1.7% in 2000 to 4.9% in 2010, an almost threefold increase, mainly due to India's huge export volumes of computer and business services (Table 1). ASEAN economies have also improved their world shares in computer, BPS, and insurance services exports. In particular, the Philippines and Singapore are major exporters of business and computer services, while other ASEAN economies have yet to realize their full potential.

India (within South Asia) and the Philippines (within ASEAN) have emerged as the major Asian economies for the export of ICT-enabled services and BPS. India is an established player and its edge in ICT-enabled services is due to a large pool of skilled ICT professionals and entrepreneurs. India has also gradually expanded its business process outsourcing (BPO) industry. The Philippines has been successful primarily in the segment of its BPO industry concentrating in voice-based services, such as call centers, which are considered low-end services. The Philippines has a comparative advantage in BPO due to the availability of sufficient manpower with good English language proficiency and the basic skills required for the BPO industry.

In 2012, India's exports of ICT-related and BPS crossed $90 billion, in which BPS exports were $24.6 billion. India's BPS exports grew by a compound average growth rate of 24.8% in 2002–2012. Over the same period, the Philippines increased

[6]Trade in ICT-enabled services and BPS can take place through all four modes of trade in services. In our analysis, we have used balance of payments (BOP) data on services exports that cover Mode 1 (cross-border trade between residents and nonresidents). According to the WTO (2005), BOP data on services exports can be seen as the upper limit of outsourcing of these services because outsourcing of ICT-enabled services and BPS is a subcomponent of overall activities covered in the export of these services. Therefore, data reported for outsourcing would differ from that of cross-border trade. For example, the United Nations Conference on Trade and Development estimates that the total world market for the offshoring of ICT-enabled services and BPS was $93 billion in 2008, which represents less than half the ICT cross-border trade of over $224 billion (UNCTAD 2009). India, Canada, the Philippines, Ireland, and the PRC comprise the bulk (80%) of this offshoring market, although their cumulative share is declining over time as new economies enter the market.

Table 1. **Shares of World Services Exports**
(%)

	2000				2010				Absolute Change in Shares			
	World	ASEAN	East Asia	South Asia	World	ASEAN	East Asia	South Asia	World	ASEAN	East Asia	South Asia
Commercial services	100	4.5	11.3	1.3	100	5.3	12.6	3.4	0	0.8	1.3	2.1
Modern services	100	3.8	12.7	1.7	100	4.0	12.5	4.9	1	0.2	−0.2	3.1
Computer and information	100	1.3	6.4	24.0	100	3.3	5.3	27.2	10	2.0	−1.1	3.2
Telecommunications	100	1.1	1.8	1.1	100	1.5	1.6	1.6	22	0.4	−0.2	0.5
Business and professional	100	4.7	16.8	0.3	100	4.9	16.4	2.6	1	0.2	−0.3	2.3
Insurance and financial	100	2.9	8.9	0.7	100	5.3	6.9	2.5	4	2.4	−1.9	1.8
Others	100	3.7	10.7	0.8	100	2.5	13.3	1.8	2	−1.2	2.6	0.9
Traditional services	100	5.1	10.2	0.9	100	6.8	12.8	1.8	0	1.7	2.5	0.8
Transportation	100	4.9	14.9	0.9	100	6.6	16.8	1.9	1	1.4	1.2	2.0
Travel	100	5.2	6.7	0.9	100	6.9	9.3	1.6	1	1.1	1.1	1.4

ASEAN = Association of Southeast Asian Nations.
Note: Figures are regional shares of world exports of services by type of service.
Sources: Authors' calculations based on United Nations (UN). 2010. *Manual on Statistics of International Trade in Services.* Washington, DC; World Bank. 2012. *World Development Indicators*. Washington, DC.

Table 2. **Exports of Modern Services**

	Value in 2000 ($ billion)				Value in 2010 ($ billion)				CAGR (%)			
	World	ASEAN	East Asia	South Asia	World	ASEAN	East Asia	South Asia	World	ASEAN	East Asia	South Asia
Commercial services	1,501	68	169	19	3,862	206	488	131	10	12	11	21
Modern services	641	25	81	11	2,047	83	256	99	12	13	12	25
Computer and information	31	0.4	2.0	7.5	211	7	11	57	21	33	19	23
Telecommunications	17	0.2	0.3	0.2	60	0.9	0.9	1	13	17	12	18
Business and professional	289	14	48	1	890	44	146	23	12	12	12	38
Insurance and financial	99	3	9	1	318	17	22	8	12	19	10	28
Others	204	8	22	2	568	14	75	10	11	6	13	19
Traditional services	860	44	88	8	1,815	123	232	32	8	11	10	15
Transportation	374	18	56	3	840	55	141	16	8	12	10	17
Travel	486	25	32	4	976	68	91	16	7	10	11	14

ASEAN = Association of Southeast Asian Nations, CAGR = compound annual growth rate.

Sources: Authors' calculations based on United Nations (UN). 2010. *Manual on Statistics of International Trade in Services.* Washington, DC; World Bank. 2012. *World Development Indicators*. Washington, DC.

its BPS exports to $9.6 billion on a compound annual growth rate of 43.3%. Considering that its GDP is only one-seventh the size of India's, the Philippines has been Asia's star performer in terms of BPO services exports. Analysis of the composition of services sector exports in India and the Philippines reveals a stark difference. BPS exports from the Philippines comprised 7% of the services sector total output (value-added) in 2012, up from only 0.6% in 2002. In comparison, India's BPS exports accounted for 2.5% of the services sector output in 2012.

Labor productivity in the services sector in the Philippines posted an annual growth rate of only 1.8% in 2000–2010, suggesting that a shift toward high-end services exports is needed (Park and Shin 2013). In India, the average annual growth rates in labor productivity in 2000–2005 was 5.4%, which was more than double the labor productivity of the industry sector in India over the same period. India has a competitive edge in ICT-enabled and knowledge-based services that has been gained by leveraging high value-added ICT-enabled and business processes services. The National Association of Software and Services Companies of India is providing strategic direction for the industry's sustainable growth. Similarly, the ICT and Business Process Association of the Philippines (IBAP) is helping investors set up businesses in the Philippine ICT and BPO industries. IBAP aims to double ICT-enabled and BPO services exports to $25 billion between 2012 and 2016. Going forward, IBAP will need to support the establishment of new business ventures offering high-end services.

III. Data on Bilateral Services Trade

Unlike the systematic and sufficiently disaggregated data on bilateral goods trade, services trade data are insufficient both in terms of disaggregation and coverage. The three primary sources for bilateral services trade data are Eurostat, the OECD, and the United Nations (UN). Eurostat provides bilateral services trade data for 27 EU economies and 66 possible partners. Although Eurostat provides bilateral services data going back to 1985, there are very few observations for earlier years and only a small portion of the early data is disaggregated. The OECD database provides data for 30 reporting economies and more than 200 possible partner economies. However, most OECD data are reported for the same 66 partner economies as Eurostat. The UN's disaggregation of bilateral services trade data has improved over time; however, there are few observations for disaggregated categories of services. The UN database includes the entire UN classified list of economies as partner economies. Again, the number of partner economies with data availability varies for each reporting economy. None of the reporting economies provide data for all partner economies in any of the datasets.[7]

[7]These three data sources broadly follow the BOP classification for services trade.

The reporting for services trade is not free from economy bias, concealed data, and overestimation and underestimation. For example, in 2003, the US reported $420 million in imports of business, professional, and technical services from India, while India reported $8.7 billion in business, professional, and technical exports to the US (GAO 2005). Such differences in data reporting are due to several reasons, including weak reporting on the import of services, intentional underreporting or overreporting, use of different definitions of cross-border services trade, and sensitivity of data. Further, sample surveys of the firms exporting services are more representative compared with surveys of firms importing services. Exporting firms can easily be covered in surveys, while importing firms are usually more numerous due to the nature of the use of imported services by domestic firms.

In our dataset for bilateral services, we find significant differences in the reporting of bilateral trade flows. For example, the US, despite being a major trading partner of many economies in the world, reports few bilateral trade flows. Vast differences in the reporting highlight underlying weaknesses in the compilation and coverage of bilateral services trade flows. As a result of these issues and the nonreporting of certain bilateral trade figures by individual economies in the reported data, we used data extracted from OECD, Eurostat, and UN data sources to arrive at bilateral services trade figures.

Initially, we extracted bilateral services import and export data between 2002 and 2011 for all possible reporting and partner economies from three data sources: the OECD, Eurostat, and the UN.[8] For our analysis, we selected the main modern services subcategories: BPS, computer and information services, and telecommunications services. We merged bilateral data flows for these subcategories from three databases and compiled a single dataset. We used this basic dataset to extract bilateral services exports of developing economies from the import data of importing OECD economies using mirror flows. Using three different datasets from Eurostat, OECD, and UN services trade data, 30 reporting economies were selected for which relatively consistent data with respect to same partner economies were available (Table 6). However, none of the reporting economies provide data for all of its partner economies in any of the datasets.

IV. Analytical Framework

In the international trade literature, the gravity model has been widely used to examine trade flows between trading partners. The basic gravity model was introduced by Tinbergen (1962) and its log-linear form specifies that the trade

[8]Recently, Francois and Pindyuk (2013) compiled comprehensive data on the services trade using Eurostat, OECD, and UN data sources. While the time period covered extends until 2010, there are few values for 2010. We prefer to create our own dataset because we had additional data for 2010–2011 and better coverage for some of the developing economies.

flows between two trading partners can be explained by the economic size of the trading partners, the distance between them, and other factors that can affect trade. The empirical application of this model has been very successful in economics (Anderson and Wincoop 2003).

Anderson (1979) provided a basic theoretical framework for a gravity model of trade flows that later was extended by others.[9] Given basic assumptions of homothetic preferences for traded goods across economies and using the constant elasticity of substitution preferences, Anderson (1979) derived the following specification of a gravity-type equation:

$$X_{ij} = \frac{m_i \phi_i Y_i \phi_j Y_j}{\sum_j \phi_j Y_j} \cdot \frac{1}{f(d_{ij})} \cdot \left[\sum_j \frac{\phi_j Y_j}{\sum_j \phi_j Y_j} \cdot \frac{1}{f(d_{ij})} \right]^{-1} u_{ij} \tag{1}$$

where,

X_{ij} = exports of economy i to economy j
Y_i = income in economy i
d_j = distance between economy i and economy j
$Ø_i$ = share of expenditure on all traded goods and services in total expenditure of economy $i = F(Y_{ij}, N_i)$, where N is the population in economy i

The standard form of the gravity equation used in empirical studies can be given as

$$X_{ij} = \alpha Y_i^{\beta_1} Y_j^{\beta_2} N_i^{\beta_3} N_j^{\beta_4} d_{ij}^{\beta_5} U_{ij} \tag{2}$$

According to Anderson (1979), with the log-linear function of Ø and m, Equation (1) resembles Equation (2) with an important difference. This difference is the square bracket term in Equation (1) $[\sum_j \frac{\phi j Y j}{\sum_j \phi_j Y_j} \cdot \frac{1}{f(d_{ij})}]^{-1}$. This is missing in the generally used empirical specification of the gravity model presented in Equation (2). Anderson (1979, 113) describes this term as follows: "the flow from i to j depends on economic distance from i to j relative to a trade-weighted average of economic distance from i to all points in the system."

Omission of this important relative economic distance term in the empirical specification of the gravity model leads to biased estimates. This is because the error term is affected by the relative economic distance term. Therefore, $E(U_{ij}) \neq 0$ and the normality assumption of ordinary least squares (OLS) is violated. This problem leads to "heteroskedastic error terms and the log-linearization of the empirical model in the presence of heteroskedasticity leads to inconsistent estimates because the expected value of the logarithm of a random variable depends on higher-order

[9]For example, Bergstrand (1985, 1989) and Deardorff (1995) derived the gravity equation from the Heckscher–Ohlin model, while Eaton and Kortum (2002) developed a theoretical justification of the gravity equation from the Ricardian model.

moments of its distribution" (Kalirajan 2007, 92). Therefore, the OLS estimation for such gravity equations will be biased.

Measuring the correct specification of the relative economic distance term is difficult because researchers do not know all the factors affecting this term. The economic distance can be affected by many factors—institutional, regulatory, cultural, and political—that are difficult to measure completely. These factors are referred to as behind-the-border constraints. The correct empirical specification of the gravity equation is still a challenge despite many proposals to partly solve the inherent bias in the standard gravity model. For example, some suggest using fixed effects models (e.g., Bayoumi and Eichengreen 1997), while Egger (2008) suggests the use of panel data models, which are nonlinear in terms of trade costs. Feenstra (2002) uses price differences between trading partners in his specification of the gravity model. Since McCallum (1995), many empirical papers have used remoteness variables, generally defined by $\sum_{m \neq j} d_{im}/y_m$, where d is distance, y is GDP, and the whole term represents the weighted average distance of economy i from all its trading partners except partner j. Anderson and Wincoop (2003) criticize these remoteness variables and suggest another multilateral resistance term. However, these solutions are either not based on the basic theory of the gravity model or cannot fully capture the inherent bias in the empirical estimation. These also give biased results by not addressing the heteroskedasticity and nonnormality of the error term, as previously discussed.

Drawing on Kalirajan (2007), this study uses a stochastic frontier approach to estimate the gravity model, taking into account heteroskedasticity and nonnormality because we do not know the structure of heteroskedasticity in a gravity equation.[10] With a stochastic frontier approach, the gravity equation can be written as

$$X_{ij} = f(Z_{ij;}\beta) \exp(v_{ij} - u_{ij}) \tag{3}$$

where

X_{ij} = actual exports from economy i to economy j
Z_{ij} = potential exports from economy i to economy j
β = a vector of unknown parameters
u_{ij} = single-sided error term for the combined effects of inherent economic distance bias or behind-the-border constraints, which is specific to the exporting economy with respect to the particular importing economy, creating the difference between actual and potential bilateral trade; normally assumed to have a truncated normal distribution

[10] Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977) were the first to introduce stochastic production frontier models, which have been used extensively in the production economics literature. Kalirajan (2000) formally introduced this approach in trade to address the inherent bias in the conventional gravity model of trade and to estimate potential trade flows.

v_{ij} = double-sided error term that captures the impact of inadvertently omitted variables and measurement errors that are randomly distributed across observations in the sample; normally assumed to follow a normal distribution with mean 0 and constant variance.

If u_{ij} is 0, then the economic distance bias and behind-the-border constraints are not important. If u_{ij} is close to 1, then these constraints prevent trade from reaching its potential (Kalirajan 2007). Thus, unlike the conventional method of the gravity estimation, the stochastic frontier approach does not exclude the effect of economic distance on bilateral trade in the gravity estimation. Equation (3) can be rewritten as

$$\ln X_{ij} = \alpha + \beta_{.1} \ln Y_i + \beta_{.2} \ln Y_j + \beta_{.3} \ln d_{ij} + \varphi R - u_{ij} + v_{ij} \tag{4}$$

R is a vector of other variables normally used in augmented gravity models. In Equation (4), it is assumed that the one-sided error term, u, which concerns the economic distance bias or behind-the-border constraints, follows a half normal distribution:

$$f_u(u) = \frac{1}{\sigma_u \sqrt{\pi/2}} e^{-\frac{1}{2}} \frac{u^2}{\sigma_u^2} \text{ if } u > \text{ or } = 0$$

$$= 0 \text{ otherwise.}$$

The statistical error term v follows a full normal distribution. Thus, with these combined error terms, neither OLS nor any variant of OLS can be used to estimate Equation (4). Instead, the maximum likelihood estimation (MLE) technique can be used. Given these density functions of half normal and full normal distributions for u and v, respectively, the density function of $\ln X$ in Equation (4) can be derived using the density functions of $u + v$:

$$f_x(\ln X) = \frac{1}{\sigma \sqrt{\pi/2}} \left\{ 1 - F \left[\frac{u+v}{\sigma} \left(\sqrt{\frac{\gamma}{1-\lambda}} \right) \right] \right\} e^{-\frac{1}{2}\left(\frac{u+v}{\sigma}\right)^2}$$

$$-\infty < \ln X < +\infty$$

where $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \frac{\sigma_u^2}{\sigma^2}$ is an indicator of the relative importance of v, which is the impact of behind-the-border constraints on potential exports. The likelihood function, which is the probability density of obtaining the sample ($\ln X_1$,$\ln X_2$, ... $\ln X_n$) may be written as

$$L^*(\ln X; \theta) = \prod_{i=1}^{n} f_x(\ln X)$$

where θ is the parameter to be estimated and it is equal to β, σ^2, and γ.

The MLE method aims to find an estimate of θ, which maximizes the value of the likelihood function, and this means that the probability of the sample drawn is large (Theil 1971, 89). The MLE estimators of θ, maximizing the above likelihood function, are obtained by setting its first-order partial derivatives with respect to β, σ^2, and γ equal to 0. The MLEs of Equation (4) can be obtained through popular software such as STATA.

There are two advantages of the stochastic frontier approach as described by Kalirajan (2007). First, it estimates the complete impact of the economic distance term, separating it from the statistical error term. This enables us to see the trade impact of behind-the-border constraints, when researchers do not have full information on the behind-the-border constraints. Second, it provides potential trade estimates by using the upper limit of data that comes from economies that have the least behind-the-border resistance.

A. Data on Explanatory Variables

The empirical specification of our gravity model includes the basic explanatory variables suggested by the analytical framework discussed in the previous section (Appendix). These include the combined GDP of the trading partners, distance between them, and language and colony variables.[11] We focus on ICT-enabled services exports that are greatly affected by the availability of a tertiary-educated population and the use of ICT infrastructure. Therefore, in our empirical specification, we include the stock of tertiary graduates and Internet subscribers per 100 persons. Data for the variables on GDP and Internet subscribers were taken from the World Bank's *World Development Indicators*. The stocks of tertiary graduates were estimated using the base stocks of graduates from Barro (2010) and tertiary enrollment, obtained from the online database of the United Nations Educational, Scientific, and Cultural Organization.[12] Distance, common language, and colony variables were downloaded from the French Research Center in International Economics. We also compiled a variable for the time difference between trading partners using information on time zones. Due to strong collinearity between the distance variable and time difference, we dropped this variable from the main regressions.

The model also specifies the variables that are either expected to augment or diminish trade between trading partners. These include a services trade agreement between the trading partners and the STRIs of importing economies. To create a dummy variable for a services trade agreement between trading partners, we used the

[11] GDP is in constant 2005 prices and the GDP deflator for the base year 2005 has been used to deflate services exports.

[12] There are missing observations in the data for graduates and enrollment of tertiary education. We fill missing observations for an economy using available information on the economy and regional averages.

information on the WTO website for effective bilateral and regional trade agreements for goods and services. The dummy variable takes a value of 1 if the trading partners belong to an effective trade agreement that also includes services. For our analysis, we excluded trade agreements that only impact the goods trade and do not cover services. Finally, we used STRIs to include barriers to the services trade in our model. An explanation of STRIs is provided below.

Barriers to trade in services are difficult to measure compared to tariffs and nontariff barriers to trade in goods. Most barriers to the services trade are in the form of regulations. Construction of an STRI first requires the careful selection of policies and regulations potentially restricting trade in services (Grosso et al. 2015). Applied regulations and policies are quantified and then converted into an index by assigning appropriate weights to each policy. To obtain more specific STRIs, we also need to separate policy measures affecting different modes of services trade. The first comprehensive effort to construct sector-specific STRIs was made by the Australian Productivity Commission (Findlay and Warren 2000) and has been widely quoted in the services trade literature. The index covers six services subsectors and 34 economies. Grünfeld and Moxnes (2003) use this STRI in their gravity model for total services trade, but they have been criticized by Kimura and Lee (2006) because the use of six services industry STRIs for the overall services trade can produce misleading results. With the availability of more disaggregated bilateral services trade data, it is possible to test the index for individual subcategories of services. However, the index is based on information for the latter years of the 1990s and is not suitable for the more recently available bilateral services trade data that includes expanded coverage.

Recent attempts involving the construction of STRIs include projects by the OECD (OECD 2009 and Grosso et al. 2015) and the World Bank (Borchert, Gootiiz, and Mattoo 2012). The STRIs derived by the OECD are only for OECD economies, while the World Bank covers 79 developing and transition economies, and 24 OECD economies. The World Bank survey covers financial services, telecommunications, retail distribution, transportation, and professional services. The OECD provides STRIs for telecommunications, construction, BPS, and computer-related services. The World Bank project has greater economy coverage than the OECD project. However, sector-specific STRIs for computer services and BPS are not available in the World Bank database. Therefore, we used STRIs compiled by the OECD for our estimations as OECD economies are the trading partners considered for the gravity models used in this paper. The OECD STRIs cover restrictions on foreign ownership, market entry, and the movement of people; discriminatory measures; public ownership; barriers to competition; and regulatory transparency and licensing (OECD 2009). In order to construct the index, each measure has been allocated a weight according to importance of that measure in terms of trade restrictiveness. Further, these policy measures are categorized by the modes of supply. In our

analysis, we used the STRIs that pertain to cross-border trade. Overall, STRI value is scaled from 0 to 1, where 0 reflects minimum trade restrictions.[13]

B. Maximum Likelihood Estimates

The gravity-type stochastic frontier model discussed above was estimated using the maximum likelihood method. Separate stochastic frontier models were estimated for the export of computer and information services, BPS, and telecommunications services (Tables 3, 4, 5). The estimations were performed on annual bilateral services exports for the period 2002–2011. We provide estimation results for the regions of South Asia, East Asia, ASEAN, Europe, and the Americas. As the STRI variable is available only for OECD economies, each exporting economy's trading partners are limited to OECD economies.[14] The stochastic frontier model was estimated using STATA software (version 11).

First, the gamma coefficient, which is the ratio of the variation in exports due to behind-the-border constraints to total variation in exports, in all the regressions is significant and close to 1, which is the upper limit for a gamma coefficient. A significant gamma coefficient shows that the use of the stochastic frontier method to estimate the gravity model is appropriate for the sample data. This also shows that there are economy-specific, behind-the-border constraints that are not captured by other explanatory variables. In developing economies, some of the important behind-the-border constraints in services—particularly BPS, computer and information services, and telecommunications services—are electricity supply interruptions and chaotic urban transportation. For example, India suffers severe power supply shortages. Many cities that are known for their active participation in the aforementioned services industries, such as Chennai, regularly experience power shortages and interruptions. Thus, state and central governments urgently need to rectify the power supply situation in their respective economies. Though the economy-specific, behind-the-border constraints could not be identified in this study due to a lack of comparable data across the sample economies, some conjectures can be made. For example, exports of modern services from developing economies may be constrained by weak regulations, lack of modern infrastructure, and domestic political interests. These factors prevent developing economies from reaching their export potential.

The coefficients of the standard gravity variables generally exhibit signs in accordance with gravity trade theory. Services exports increase with a rise in the GDP

[13] STRI data by service classification, type of restriction, and mode of service was made available during the OECD experts meeting on the STRI held in Paris on 2–3 July 2009. See http://www.oecd.org/tad/services-trade/oecdexpertsmeetingsontradeinservices.htm. For more information on STRI data, see http://www.oecd.org/tad/services-trade/services-trade-restrictiveness-index.htm.

[14] Among OECD economies, we excluded the Czech Republic, Slovakia, and Slovenia due to a lack of comparable data.

Table 3. **Maximum Likelihood Estimation Results of Stochastic Frontier Model**
(Exports of Business and Professional Services)

	All Economies		South Asia		East Asia and ASEAN		Europe and the Americas	
Log of exporters' real GDP	0.683***		1.221***		0.535***		0.684***	
	(0.028)		(0.119)		(0.066)		(0.024)	
Log of importers' real GDP	0.896***	0.952***	0.787***	0.762***	1.127***	1.096***	0.767***	0.832***
	(0.032)	(0.035)	(0.111)	(0.108)	(0.069)	(0.057)	(0.031)	(0.038)
Colony	0.222	0.540*	1.270	1.836*	−0.352	−0.288	0.277	0.534
	(0.227)	(0.290)	(0.755)	(0.833)	(0.537)	(0.605)	(0.219)	(0.273)
Common language	0.649***	0.510***	−0.306	−0.208	0.794**	0.274	0.726***	0.737***
	(0.148)	(0.194)	(0.486)	(0.549)	(0.309)	(0.361)	(0.157)	(0.194)
Log of distance	−0.981***	−0.998***	0.038	0.073	−0.690***	−0.743***	−0.889***	−0.862***
	(0.042)	(0.054)	(0.731)	(0.817)	(0.236)	(0.266)	(0.041)	(0.048)
Services Trade Restrictiveness Index (STRI)	−12.045***	−12.405***	−10.414*	−10.582*	−19.146***	−18.534***	−9.031***	−8.874***
	(1.540)	(1.951)	(4.703)	(4.879)	(3.252)	(2.901)	(1.542)	(1.698)
FTA_services	0.020	−0.019			−0.106	−0.098	0.150	−0.037
	(0.079)	(0.087)			(0.111)	(0.116)	(0.123)	(0.153)
Log of internet users per 100 persons_i	0.237***	0.394***	0.376***	0.634***	0.155***	0.317***	0.230***	0.256***
	(0.031)	(0.031)	(0.133)	(0.175)	(0.053)	(0.046)	(0.059)	(0.060)
Log of internet users per 100 persons_j	0.154***	0.162***	1.048***	1.033***	0.282**	0.480***	0.089	0.020
	(0.053)	(0.055)	(0.234)	(0.228)	(0.124)	(0.113)	(0.056)	(0.060)
Log of tertiary graduates_i		0.398***		1.171***		0.125**		0.597***
		(0.024)		(0.150)		(0.045)		(0.025)
Constant	−6.253***	−2.311***	−25.928***	−19.276*	−9.939***	−5.370**	−6.242***	−3.086***
	(0.727)	(0.689)	(6.155)	(7.529)	(2.498)	(2.617)	(0.622)	(0.690)
Gamma	0.86***	0.900***	0.830***	0.880***	0.850***	0.880***	0.830***	0.880***
Log likelihood	−4,083.1	−3,933.100	−196.9	−198.070	−1,353.3	−1,370.5	−2,259	−2,057.4
Wald Chi^2	2,533.5	1,816.1	259	181.3	610.7	685.5	1,881	1,056.8
No. of Obs.	4,940	4,489	258	258	1,375	1,362	3,307	2,869

ASEAN = Association of Southeast Asian Nations, FTA = free trade agreement, GDP = gross domestic product.
Notes: *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance. Figures in parentheses are standard errors.
Source: Authors' calculations.

Table 4. **Maximum Likelihood Estimation Results of Stochastic Frontier Model**
(Exports of Computer and Information Services)

	All Economies		South Asia		East Asia and ASEAN		Europe and Americas	
Log of exporters' real GDP	0.520***		1.575***		0.339***		0.458***	
	(0.044)		(0.157)		(0.075)		(0.042)	
Log of importers' real GDP	0.818***	0.821***	1.521***	1.480***	0.963***	0.922***	0.630***	0.625***
	(0.054)	(0.058)	(0.163)	(0.173)	(0.101)	(0.111)	(0.049)	(0.054)
Colony	0.263	0.491	−0.829	−0.224	0.021	0.020	0.324	0.544
	(0.335)	(0.394)	(1.342)	(1.409)	(0.608)	(0.634)	(0.300)	(0.345)
Common language	0.862***	1.004***	1.208	1.119	1.105**	0.982**	0.484**	0.590**
	(0.224)	(0.234)	(0.969)	(1.123)	(0.380)	(0.393)	(0.215)	(0.249)
Log of distance	−0.795***	−0.823***	0.333	0.210	−0.671**	−0.703**	−0.565***	−0.521***
	(0.063)	(0.074)	(1.222)	(1.364)	(0.304)	(0.324)	(0.064)	(0.073)
Services Trade Restrictiveness Index (STRI)	−7.106**	−7.560**	−21.294***	−18.295**	−17.285**	−14.712**	−6.788**	−9.141**
	(3.048)	(3.508)	(5.137)	(6.039)	(6.950)	(7.459)	(2.832)	(3.111)
FTA_services	0.053	0.021			−0.063	−0.040	−0.028	−0.349
	(0.123)	(0.131)			(0.178)	(0.181)	(0.186)	(0.208)
Log of internet users per 100 persons_i	0.424***	0.484***	0.598**	0.620***	0.225***	0.323***	0.547***	0.421***
	(0.048)	(0.050)	(0.270)	(0.261)	(0.084)	(0.084)	(0.068)	(0.077)
Log of internet users per 100 persons_j	0.511***	0.292***	1.408**	1.197**	0.180	0.200	0.643***	0.464***
	(0.073)	(0.092)	(0.590)	(0.561)	(0.237)	(0.241)	(0.068)	(0.083)
Log of tertiary graduates_i		0.315***		1.592***		0.181**		0.366***
		(0.038)		(0.157)		(0.073)		(0.040)
Constant	−6.171***	−1.162	−39.553***	−35.559***	−8.190*	−4.972	−7.336***	−3.308***
	(1.130)	(0.861)	(9.067)	(10.483)	(3.256)	(3.406)	(0.857)	(0.863)
Gamma	0.86***	0.88***	0.88***	0.85***	0.82***	0.84***	0.88***	0.88***
Log likelihood	−4,114.9	−3,850.7	−469.4	−464.6	−1,082	−1,078	−1,970.8	−1,763.5
Wald Chi^2	1,611.1	1,249.6	529.29	456.3	266.4	225.8	1,416.9	1,085.8
No. of Obs.	3,532	3,196	277	277	841	835	2,414	2,084

ASEAN = Association of Southeast Asian Nations, FTA = free trade agreement, GDP = gross domestic product.
Notes: *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance. Figures in parentheses are standard errors.
Source: Authors' calculations.

Table 5. **Maximum Likelihood Estimation Results of Stochastic Frontier Model**
(Exports of Telecommunications Services)

	All Economies	South Asia	East Asia and ASEAN	Europe and Americas
Log of exporters' real GDP	0.505***	0.766***	0.230***	0.530***
	(0.031)	(0.249)	(0.069)	(0.031)
Log of importers' real GDP	0.698***	0.367**	0.832***	0.586***
	(0.037)	(0.172)	(0.095)	(0.035)
Colony	0.353*	1.026	1.485*	0.124
	(0.212)	(1.534)	(0.882)	(0.186)
Common language	0.590***	−0.010	0.772	0.331*
	(0.165)	(0.997)	(0.492)	(0.151)
Log of distance	−0.730***	2.776	−0.504	−0.704***
	(0.047)	(2.216)	(0.892)	(0.045)
Services Trade Restrictiveness Index (STRI)	−0.959	−2.067	1.302	−1.682
	(1.277)	(10.607)	(2.834)	(1.321)
FTA_services	0.514***		0.137	0.283*
	(0.133)		(0.333)	(0.134)
Log of internet users per 100 persons_i	0.249***	0.215*	0.056	0.463***
	(0.044)	(0.103)	(0.068)	(0.081)
Log of internet users per 100 persons_j	0.487***	1.155**	0.830***	0.412***
	(0.077)	(0.473)	(0.232)	(0.077)
Constant	−6.349***	−42.006**	−9.511	−8.216***
	(0.697)	(16.174)	(8.573)	(0.676)
Gamma	0.78***	0.79***	0.78***	0.77***
Log likelihood	−2,366.1	−232.5	−543	−1,617.2
Wald Chi^2	1,085.6	115.9	261.3	863.7
No. of Obs.	2,747	176	559	2,012

ASEAN = Association of Southeast Asian Nations, FTA = free trade agreement, GDP = gross domestic product.
Notes: *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance. Figures in parentheses are standard errors.
Source: Authors' calculations.

of exporters and importers, and decrease with an increase in the distance between them. The GDP coefficients for both exporters and importers are highly significant. The coefficient of distance in the regression for South Asia is positive and not significant for computer and information services, BPS, and telecommunications services. This is in line with the idea that most computer services, ICT-enabled services, and BPO exports from South Asia are generated by offshore service providers based in India and delivered online.[15] Second, an increase in distance also provides opportunities for South Asia to provide customer support services, back office services, some data processing, and the processing of medical transcripts to economies in different time zones.[16] Compared with South Asia, the distance

[15]BPO includes a large number of services that firms can outsource offshore. Exports of services that come from BPO operations can have entries under different BPO service classifications, including computer services, information services, other business services, and telecommunications services.

[16]We also used the time difference between the bilateral trade partners in separate regressions and found that the coefficient of time difference was also positive and not significant for South Asia, while it was negative and significant for our overall sample.

coefficient for East Asia and ASEAN is negative and significant in the regression for BPS and computer and information services exports. This may be because the BPS exports of East Asian economies are more dependent on personal interactions compared to South Asia's BPS exports.

New ICTs have played a central role in the increase in trade in modern services. We included Internet use as a proxy for the availability and use of ICTs in an economy. The coefficients for Internet use are positive for both exporting and importing economies; however, they are more significant for exporting economies. The results show that Internet use in both trading partners is essential to augment the trade of modern services between them.

Other explanatory variables included in the empirical model exhibit theoretically correct signs for their coefficients. Although the significance of the results varies across different services categories, these are expected results. For example, sector-specific STRIs have negative and statistically significant coefficients in the regressions for BPS and computer services. In contrast, telecommunications seems little affected by the STRIs. Trade agreements that include services generally do not have significant effects on bilateral services trade. This ineffectiveness could be due to the trade agreement variable being general and not sector specific. The stock of tertiary graduates was found to be significant and to positively contribute to the export of computer-related services and BPS. For South Asia, the coefficient is larger than in other regions, showing that an increase in graduates can result in a greater rise in exports in South Asia than in East Asia or ASEAN.

C. Export Performance

This section describes the performance of the economies in our sample in terms of realizing their bilateral export potential, using economy-specific stochastic frontier estimates. As described by O'Donnell, Rao, and Battese (2008), economies exhibit different technology production opportunities due to differences in the physical, social, and economic environment in which trade or production takes place. Therefore, the estimation of separate stochastic frontiers for individual economies, under the assumption that each economy has different levels of trade technology, is reasonable for our analysis.

Economy-wise realization of export potential is provided in Table 6 for BPS, computer and information services, and telecommunications services. The realization of export potential is plotted against per capita GDP in Figure 1. The plot shows that lower-middle-income economies seem to have realized greater export potential in telecommunications services, while high-income economies appear to have realized greater export potential in BPS. It is interesting to know whether there are any specific reasons for such a pattern of realization between lower-middle-income and high-income economies. The plot of the realization of export potential against per capita R&D expenditure shown in Figure 2 indicates

Table 6. **Realization of Potential Bilateral Exports**
(Simple Average, %)

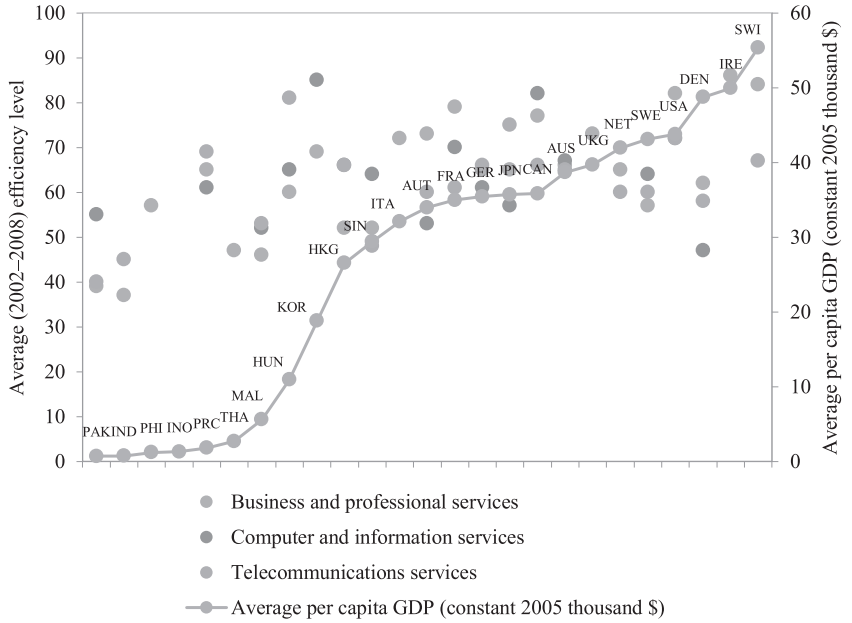
Exporter	Region	Business and Professional Services	Computer and Information Services	Telecommunications Services
India	South Asia	53	60	55
Pakistan	South Asia	39	55	40
Australia	East Asia and Pacific	66	67	65
Hong Kong, China	East Asia	52	66	66
Republic of Korea	East Asia	69	85	–
Japan	East Asia	65	57	75
People's Republic of China	East Asia	65	61	69
Singapore	ASEAN	52	64	48
Indonesia	ASEAN	37	–	45
Malaysia	ASEAN	46	52	53
Philippines	ASEAN	57	–	–
Thailand	ASEAN	47	–	–
Canada	North America	77	82	66
United States	North America	82	72	72
Austria	Europe	73	53	60
Denmark	Europe	62	47	58
France	Europe	79	70	61
Germany	Europe	65	61	66
Hungary	Europe	60	65	81
Ireland	Europe	86	–	–
Italy	Europe	72	–	–
The Netherlands	Europe	65	–	60
Sweden	Europe	57	64	60
Switzerland	Europe	84	–	67
United Kingdom	Europe	73	–	–

– = data not available, ASEAN = Association of Southeast Asian Nations.
Note: Cyprus, Finland, Greece, Luxembourg, and Romania are part of the overall sample; however, they were not included in the single-economy analysis for brevity.
Source: Authors' calculations on the basis of individual economy stochastic frontier models using data for 2002–2008.

that high-income economies—such as Germany, the US, and Switzerland—spend relatively more on R&D with respect to BPS; hence, they tend to realize larger export potential in BPS. A similar argument applies for lower-middle-income economies with respect to their realization of greater export potential in telecommunications services.

In general, results reveal that emerging economies such as the Philippines and India that have seen significant growth in their modern services exports due to the outsourcing phenomenon are still not utilizing their full potential. There is also heterogeneity in individual economy performances across the three types of services under review. For BPS exports, the overall performance of ASEAN member economies is weak, with an average realization of export potential of 50% for all economies. The Philippines leads all economies in the grouping by realizing 57%

Figure 1. **Realization of Modern Services Export Potential Exports versus GDP per Capita**



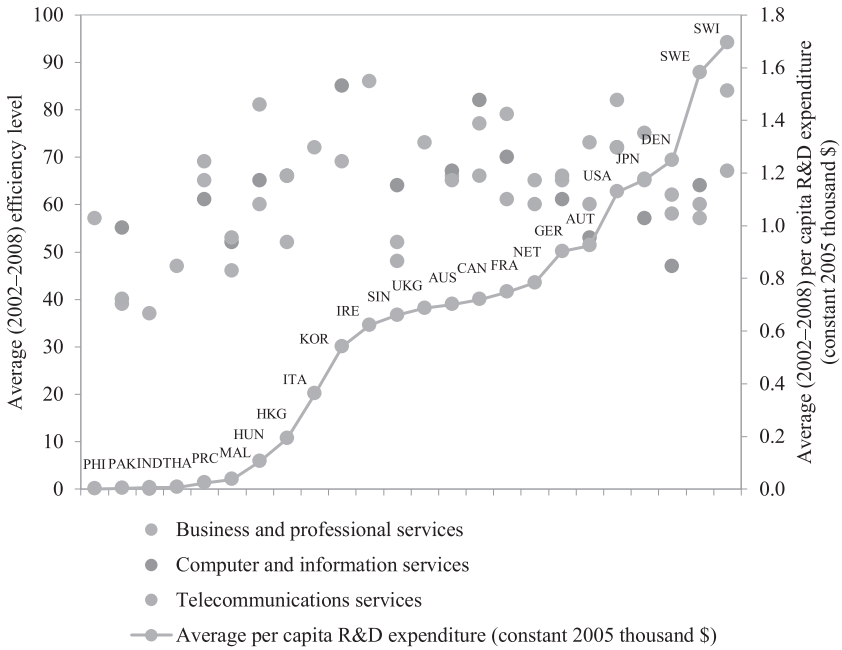
AUS = Australia; AUT = Austria; CAN = Canada; DEN = Denmark; FRA = France; GDP = gross domestic product; GER = Germany; HKG = Hong Kong, China; HUN = Hungary; IND = India; INO = Indonesia; IRE = Ireland; ITA = Italy; JPN = Japan; KOR = Republic of Korea; MAL = Malaysia; NET = the Netherlands; PAK = Pakistan; PHI = Philippines; PRC = People's Republic of China; SIN = Singapore; SWE = Sweden; SWI = Switzerland; THA = Thailand; UKG = United Kingdom; USA = United States.
Sources: Authors' calculations and World Bank. 2012. *World Development Indicators*. Washington, DC.

of its BPS export potential. The performance of India is relatively better than that of the average ASEAN economy; however, it is still considerably weaker than in East Asia, Western Europe, and North America. For example, the top performing economies—including the US, Canada, the UK, Switzerland, and Ireland—realize around 80% of their BPS export potential compared with 53% for India and an average of 50% for ASEAN.

South Asian and East Asian economies are performing relatively better in the export of computer and information services than in BPS. On average, economies in East Asia have realized their potential more than European economies, while ASEAN member economies seem on par with the European average. Again, India, despite being among the top offshore destinations for the outsourcing of computer-related services, is lagging behind other economies in terms of its realized export potential. By making use of its unrealized potential and removing behind-the-border constraints, India could accelerate its export growth, led by computer-related services and BPS.

For telecommunications services, the average export performance of East Asian economies is the highest among all other regions included in the study. This

Figure 2. **Realization of Modern Services Export Potential and R&D Expenditure per Capita**



AUS = Australia; AUT = Austria; CAN = Canada; DEN = Denmark; FRA = France; GDP = gross domestic product; GER = Germany; HKG = Hong Kong, China; HUN = Hungary; IND = India; INO = Indonesia; IRE = Ireland; ITA = Italy; JPN = Japan; KOR = Republic of Korea; MAL = Malaysia; NET = the Netherlands; PAK = Pakistan; PHI = Philippines; PRC = People's Republic of China; R&D = research and development; SIN = Singapore; SWE = Sweden; SWI = Switzerland; THA = Thailand; UKG = United Kingdom; USA = United States.
Sources: Authors' calculations and World Bank. 2012. *World Development Indicators*. Washington, DC.

may be because some economies in East Asia—such as the Republic of Korea; Japan; Hong Kong, China; and the PRC—are active players in using advanced technologies in the provision of global transmissions of voice and data. India is also doing well compared with ASEAN member economies; however, it lags behind the performance of economies in East Asia, Europe, and North America. Economies such as Pakistan and Indonesia that have very low efficiencies in terms of utilization of their export potential can adopt advanced technologies and learn from the experiences of their high-performing neighbors.

V. Conclusions and Policy Implications

For the three types of services included in our analysis, established services exporters from North America and Europe show the highest levels of performance. East Asian economies—including Hong Kong, China; the Republic of Korea; Japan; and the PRC—are also relatively efficient in their modern services exports,

particularly telecommunications services. ASEAN economies that are performing well in manufacturing are less efficient in terms of realizing their export potential in modern services. India, despite its unprecedented growth rates in the export of BPS and computer and ICT-enabled services, is also not efficiently realizing its export potential. The unrealized potential of India's modern services exports suggests that for the economy to sustain its services-based, export-led growth, continued efforts to develop high-end and knowledge-based services exports are needed, as well as the implementation of market reforms.

In order to catch up with the high-performing economies of East Asia, Europe, and North America, economies in South Asia and ASEAN should pursue best practices in their trade strategies, adopt advanced technologies, and remove behind-the-border constraints. The importance of regional cooperation in terms of relevant services trade agreements involving technology transfer and capacity building need not be overemphasized here. Identification of particular types of behind-the-border constraints that increase the gap between the actual and potential exports of modern services is beyond the scope of this paper. Nevertheless, some conjectures can be made based on field observations. Improvements in the business environment, regulatory reforms, and the provision of modern infrastructure are a few of the measures that can reduce behind-the-border constraints. Though modern services do not depend heavily on physical infrastructure, such as port facilities, the poor quality of infrastructure, including power shortages and chaotic urban transportation, hampers the growth of these services. Appropriate training and improved standards for graduates in ICT-related disciplines are also important for the growth and sustainability of modern services exports from developing economies. Our results support the view that an increase in the stock of graduates and the adoption of advanced technologies can have a significant positive impact on modern services exports from developing economies in general and South Asia in particular.

Exploiting the potential of Asian economies for modern services exports requires a diverse policy response and private sector initiatives. ICT infrastructure and well-trained graduates are the basic ingredients for ICT-enabled modern services exports. Improvements in these areas are needed in economies like Bangladesh and Pakistan as they search for their niche in a competitive global market. For established players like India, on the other hand, continuous innovation is required to move up the value chain and achieve sustainable growth beyond the current dependence on labor-cost comparative advantage. Improving urban infrastructure and developing knowledge cities is also important to facilitate the business models of modern services exports in developing Asian economies. Furthermore, the experiences of successful economies point to the role of an array of diverse factors in the expansion of ICT-enabled modern services, including multinationals, diaspora, partnerships, entrepreneurship, and regulatory reforms. Finally, there is a need for regional efforts to reduce regulatory barriers to trade in services.

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APPENDIX: Simple Correlation Matrix among Explanatory Variables

	Log of importer's real GDP	Colony	Common language	Log of distance	Services Trade Restrictiveness Index (STRI)_ importer	FTA_ services	Log of tertiary graduates_ exporter	Log of internet users per 100 persons_ exporter	Log of internet users per 100 persons_ importer
Log of importers' real GDP	1								
Colony	0.051	1							
Common language	0.064	0.187	1						
Log of distance	0.119	−0.066	−0.013	1					
Services Trade Restrictiveness Index (STRI)_importer	0.045	−0.029	−0.116	−0.029	1				
FTA_services	−0.111	−0.010	−0.064	−0.750	0.105	1			
Log of tertiary graduates_exporter	−0.073	−0.008	0.001	0.309	0.017	−0.294	1		
Log of internet users per 100 persons_exporter	0.008	0.012	−0.007	−0.304	−0.038	0.316	−0.321	1	
Log of internet users per 100 persons_importer	0.065	0.015	0.097	−0.009	−0.358	−0.007	0.059	0.093	1

Note: This correlation matrix is for all the observations used in Table 3, Column 2 regression (N = 4,489).
Source: Authors' calculations.

Foreign Direct Investment, Terms of Trade, and Quality Upgrading: What Is So Special about South Asia?

KONSTANTIN M. WACKER, PHILIPP GROSSKURTH, AND TABEA LAKEMANN*

The existing literature has highlighted the positive effect of foreign direct investment (FDI) on export upgrading and associated terms of trade in developing economies. However, the FDI effect has been found to be negative in South Asia. In this paper, we elaborate on the South Asia-specific effect by emphasizing the role of human capital in the positive link between FDI and terms of trade. We argue that education levels in South Asia have lagged behind those in East Asia and other developing regions. This has resulted in a world market integration strategy in South Asia that specializes in less skills-intensive products and generates associated FDI flows. We demonstrate these patterns for two South Asian economies (Bangladesh and Pakistan) and two East Asian economies (Malaysia and Thailand) for which historical breakdowns of FDI data are available.

Keywords: development, FDI, Prebisch–Singer hypothesis, terms of trade
JEL codes: F23, O11, O57

I. Introduction

How economies best integrate into the world economy and what types of goods and services they produce and export is subject to a vivid academic debate (e.g., Hausmann, Hwang, and Rodrik 2007; Lin 2011; Lederman and Maloney 2012). This question is also of importance because it shapes the optimal design and degree of industrial policies, especially in developing and emerging economies.

A recent strand in the literature has emphasized the role of foreign direct investment (FDI) and its effects on export unit values in this context (Harding and Javorcik 2012, Wacker [forthcoming]), as increases in the latter can either be interpreted as a measure for export upgrading or as the purchasing power of exports

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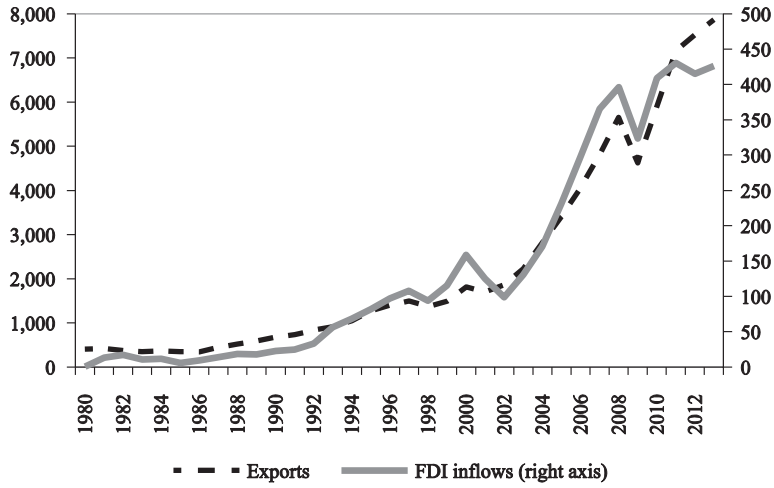
Figure 1. **FDI Inflows and Exports in Developing Asia**
($ billion)



FDI = foreign direct investment.
Notes: Values at current prices and exchange rates. Exports comprise goods and services.
Source: United Nations Conference on Trade and Development.

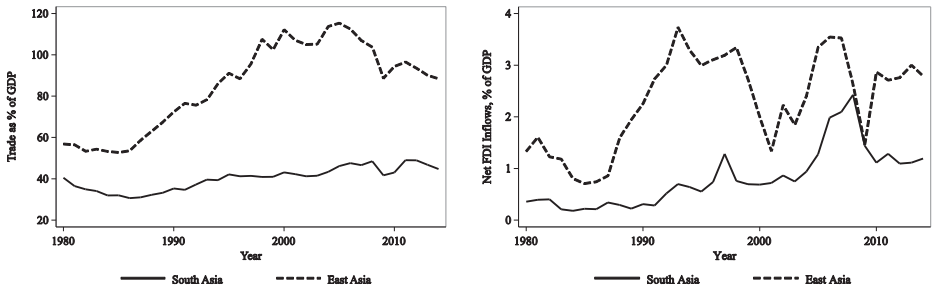
via terms of trade (i.e., export prices relative to import prices).[1] This debate thus ties in with classical arguments in development economics viewing unfavorable export prices and terms of trade trends in developing economies as a reflection of the less sophisticated goods they export, most notably commodities (Singer 1950, Prebisch 1950), with little income elasticity and unfavorable long-run perspectives (Sarkar and Singer 1991).

In a seminal paper, Singer (1950) argued that such patterns of world market integration with declining terms of trade in developing economies are widely shaped by foreign investment. This potential relationship between FDI, export patterns, and terms of trade is of special importance for South Asia and East Asia for at least two reasons.[2] First, as economic rationale suggests, FDI and export volume are highly correlated in developing Asia (Figure 1). Second, Li, Huang, and Li (2007) argued that FDI might have lowered the terms of trade in the People's Republic of China (PRC), while Wacker (forthcoming) finds a positive effect of FDI on developing economies' terms of trade, with a negative effect in South Asia constituting the only exception.

[1] The traditional terms of trade argument is emphasized, for example, by De Long and Summers (1991), Levine and Renelt (1992), and Harrison and Rodríguez-Clare (2009). Terms of trade and export unit values are closely related as the former are the ratio of export unit values to import unit values. For early contributions emphasizing the quality upgrading argument, see Schott (2004), Hummels and Klenow (2005), and Dulleck et al. (2005).

[2] Throughout this paper, we follow the World Bank's regional classifications, which group Bangladesh, India, Pakistan, and Sri Lanka into South Asia; and the PRC, Indonesia, Malaysia, the Philippines, and Thailand into East Asia.

Figure 2. **Trade Openness and FDI Inflows in South Asia and East Asia**



FDI = foreign direct investment, GDP = gross domestic product.
Notes: Values computed as unweighted averages for Bangladesh, India, Pakistan, and Sri Lanka (South Asia); and for the People's Republic of China, Indonesia, Malaysia, the Philippines, and Thailand (East Asia).
Source: World Bank. *World Development Indicators 2014*. http://data.worldbank.org/sites/default/files/wdi-2014-book.pdf

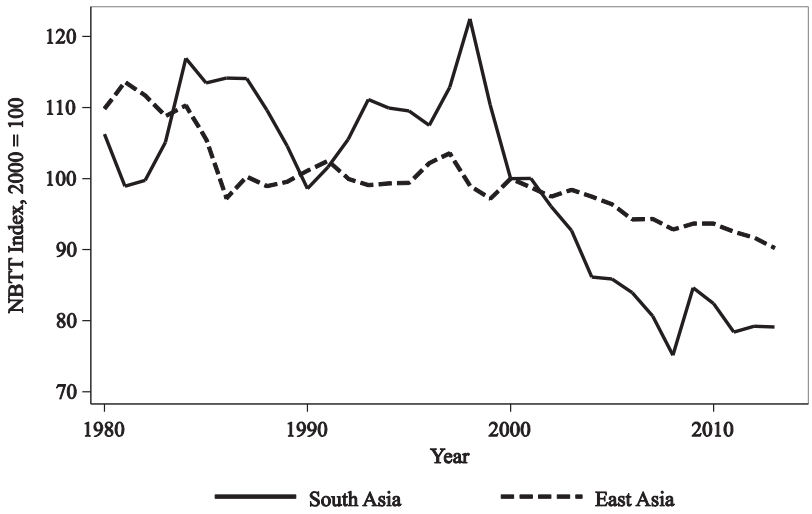
In this paper, we elaborate on the latter result. Our key argument is that South Asia and East Asia have followed two very different strategies of FDI-led world market integration. To be more precise, East Asia pursued a strategy of export upgrading and quality improvements (quality competitiveness) in line with its factor endowment, most notably a relatively educated labor force, while attracting associated types of FDI.

Furthermore, East Asia's economic development process took off relatively early and, as Figure 2 illustrates, its economies opened up earlier and more dynamically than South Asia's beginning in the late 1980s.[3] East Asian economies thus managed to seize certain export niches with according market power. With these niches occupied, later-developing South Asian economies could not simply follow the same world market integration strategy, thus making the case that an intra-Asian process of "kicking away the ladder" exists.[4] Moreover, South Asia was not equipped with a similarly educated labor force that would have been necessary for export upgrading. Instead, it conquered world market shares using a price competitiveness integration strategy. In line with this argument, when FDI started pouring into South Asia and trade openness continued to moderately increase (Figure 2), the region experienced a considerable decline in net barter terms of trade

[3]Of course, the groupings of South Asian and especially East Asian economies are heterogeneous among themselves. Generally speaking, levels of trade openness are lower in South Asia than in East Asia. Among the former, Sri Lanka stands out as being the most open. The accelerating trend in the 1980s was especially pronounced in Malaysia, the Philippines, and Thailand. The PRC, on the other hand, has long had levels of openness almost as low as the South Asian average, passing the 50% threshold only in the early 2000s. Concerning FDI, inflows to South Asia have been lowest in Bangladesh, while Sri Lanka stands out again for having experienced positive inflows in the 1980s when inflows to other South Asian economies were negligible.

[4]Our argument in this regard should not be confused with the more institutional argument of Chang (2002), who contends that developed economies are deliberately attempting to "kick away the ladder" that they have climbed through the use of industrial policies.

Figure 3. **Terms of Trade in Asia**



NBTT = net barter terms of trade.
Notes: Values computed as unweighted averages for Bangladesh, India, Pakistan, and Sri Lanka (South Asia); and for the People's Republic of China, Indonesia, Malaysia, the Philippines, and Thailand (East Asia).
Source: World Bank. *World Development Indicators 2014*. http://data.worldbank.org/sites/default/files/wdi-2014-book.pdf

(NBTT) of almost 40% in the decade following the 1997/98 Asian financial crisis (Figure 3).[5]

We support our arguments concerning different FDI-led world market integration strategies and associated terms of trade effects in South Asia and East Asia with economic arguments and a descriptive analysis of FDI and export product market data. Due to the lack of comprehensive historical FDI data with a sectoral breakdown, we rely on case studies for Bangladesh and Pakistan in South Asia, and Malaysia and Thailand in East Asia as a sectoral breakdown of historical FDI data is available for each of these economies.

Our paper is organized as follows. Section II reiterates the finding of an exceptional negative relationship between FDI and terms of trade in South Asia, and provides new econometric evidence of this relationship. Section III elaborates on the potential reasons for this South Asia-specific relationship, combining stylized facts with key economic rationales. Section IV demonstrates related patterns in FDI

[5]NBTT are calculated as the percentage ratio of the export unit value indexes to the import unit value indexes of an economy, measured relative to the base year 2000. A closer look shows that this development was mainly driven by Bangladesh and Pakistan, and to a lesser extent Sri Lanka. Indian terms of trade dropped in the aftermath of the 1997/98 Asian financial crisis, but have then risen steadily since 2004 to levels well above precrisis values. A similar, yet weaker, decline in NBTT since 1998 can be observed in Thailand, the Philippines, and the PRC. Indonesia saw an unprecedented rise in terms of trade over the same period, while figures in Malaysia remained roughly constant.

and exports, focusing on the four economies mentioned above. Section V provides a policy discussion. Section VI concludes.

II. The Special Effect of Foreign Direct Investment on Terms of Trade in South Asia: Econometric Evidence

The previous literature has pointed out several reasons why FDI should have an impact on an economy's export prices and terms of trade (e.g., Findlay 1980; Darity Jr. 1990; Li, Huang, and Li 2007; Harding and Javorcik 2012; Wacker [forthcoming]). Potential channels that this literature has highlighted include the macroeconomic transfer problem, product upgrading effects due to FDI that show up as price increases, the pricing power and markups of multinational firms, and FDI's effects on the aggregate marginal product of capital that influence terms of trade in the long run (Darity Jr. 1990).[6]

Since these effects of FDI on terms of trade operate in different directions, the question of which effect is most important essentially becomes an empirical one and motivates the study of Wacker (forthcoming) that this section largely relies on. Following the rationale that FDI should influence developing economies' terms of trade, an econometric model is estimated that explains an economy's NBTT as a log-linear function of the FDI stock relative to gross domestic product (GDP) and a set of control variables:[7]

$$\ln(NBTT)_{it} = \varphi \ln(NBTT)_{i,t-1} + \beta FDI/GDP_{it} + X_{it}\vec{\theta} + \varepsilon_{it}, \quad (1)$$

where ε includes economy and year fixed effects. As there are several endogeneity concerns, the model is estimated using System GMM (i.e., instrumenting current levels of the lagged dependent variable and of FDI stock by lags of the first-differenced series). The set of control variables in X that is motivated by previous studies on terms of trade developments mainly captures the industry structure, labor market developments, and primary macroeconomic indicators (e.g., exchange rate, real interest rate, inflation, current account balance, and trade openness). The dataset covers more than 50 developing economies during the period 1980–2008.[8]

In the estimated Equation (1) presented above, there is an economically relevant and statistically significant positive impact of FDI on developing economies' NBTT. However, given that there are ambiguous economic channels for this

[6]The transfer problem suggests an adverse impact of international monetary transfers on relative prices, see Dixit and Norman (1980), and Krugman and Obstfeld (2000) for a textbook treatment.

[7]NBTT capture the price developments of an economy's export basket relative to its import basket. They are distinct from terms of trade measures that look at commodity prices relative to manufacturing prices (often called commodity terms of trade) and do not take into account changes in trade volumes (as income terms of trade do) or productivity developments (factorial terms of trade).

[8]A detailed explanation of the dataset, its sources and summary statistics, and the econometric method used is given in Wacker (forthcoming).

relationship that might also vary geographically, it is meaningful to check for regional heterogeneity and estimate Equation (1) in the form

$$\ln(NBTT)_{it} = \varphi \ln(NBTT)_{i,t-1} + \sum_{j=1}^{6} \beta_j FDI/GDP_{it} + X_{it}\vec{\theta} + \varepsilon_{it}, \tag{2}$$

for the $j = 1, \ldots, 6$ regions (East Asia and Pacific, Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, South Asia, and Sub-Saharan Africa) as classified by the World Bank. Then, the hypothesis of equality of β-parameters for all regions can be investigated using an F-test. We find that the null hypothesis of parameter homogeneity ($\beta_j = \beta$ for all j) can easily be rejected and thus sequentially test down our model (from general to specific), using likelihood ratio tests, F-tests, and other standard model selection criteria. The overwhelming evidence from this statistical exercise is that the only β-parameter standing out is that for South Asia, covering observations of Bangladesh, India, Pakistan, and Sri Lanka.[9] That is, from a statistical perspective, the model that is best or most likely to be true for explaining dynamic developments in NBTT is of the form

$$\ln(NBTT)_{it} = \varphi \ln(NBTT)_{i,t-1} + \beta_{SA} FDI/GDP_{it} + \beta_{RDW} FDI/GDP_{it} + X_{it}\vec{\theta} + \varepsilon_{it}, \tag{3}$$

where β_{SA} is a separate parameter for South Asia and the parameter β_{RDW} describes the impact of FDI for the rest of the developing world.

Our estimation results show a strongly negative (and highly significant) impact of FDI on terms of trade for South Asia of -2.1% and a positive (and weakly significant) impact of 0.3% for the rest of the developing world in the first column of Table 1 (both are long-run parameters, calculated as $\beta/[1 - \varphi]$). Concerning the control variables, few of them turn out to be statistically significant, although standard errors are often of reasonable size compared to the estimated parameters. The distributed lag specification of the current account balance, motivated by the findings of Santos-Paulino (2010), and the differing prefix on the lag structure support a dynamic response of terms of trade to the current account. There is some evidence that the actual deviation from the long-run growth rate positively impacts terms of trade, supporting an economic relationship between business cycle fluctuations and terms of trade that is beyond the scope of this paper (see Prebisch 1950, and Thirlwall and Bergevin 1985 for more on the issue). Membership in a

[9] It was also investigated whether the different impact in South Asia is driven by individual economies. For this purpose, one South Asian economy at a time and any set of two South Asian economies at a time have been excluded from the regression. In each case a similar picture emerged, rejecting the suspicion that the effect is driven by individual economies.

Table 1. **Regression Results**

Dependent Variable: ln(NBTT)			
ln(NBTT) (−1)	0.7076***	0.7065***	0.7238***
	(0.2084)	(0.2439)	(0.1903)
FDI stock/GDP for South Asia (−1)	−0.0060***	−0.0062***	−0.0063***
	(0.002)	(0.0022)	(0.0022)
FDI stock/GDP for rest of the world (−1)	0.0009**	0.0009**	0.0009**
	(0.0003)	(0.0004)	(0.0004)
Agricultural and raw material exports (%)	0.0020	0.0019	0.0018
	(0.0016)	(0.0018)	(0.0015)
Current account balance (% of GDP)	0.0058***	0.0057	0.0045***
	(0.0015)	(0.0040)	(0.0015)
Current account balance (% of GDP) (−1)	−0.0028*	−0.0029	−0.0020
	(0.0014)	(0.0028)	(0.0014)
Real GDP per capita	0.0000		
	(0.0000)		
Inflation (annual %)	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
Manufacturing exports (%)	−0.0000		
	(0.0003)		
Real interest rate	−0.0000		
	(0.0006)		
Services value-added (% of GDP)	0.0004		
	(0.0008)		
Deviation from long-run growth	0.4356**	0.4453	
	(0.1682)	(1.5110)	
Deviation from long-run growth (−1)	0.0258		
	(0.2118)		
Unemployment rate	0.0013	0.0015	0.0012
	(0.0010)	(0.0015)	(0.0008)
Regional Trade Agreement membership	−0.0351**	−0.0378**	−0.0414***
	(0.0172)	(0.0187)	(0.0142)
No. of instruments	44	39	38
Hansen test (p-value)	0.994	0.748	0.857
AR Bond z statistic for AR(1)	−2.39	−2.56	−2.46
AR Bond z statistic for AR(2)	−1.14	−0.57	−0.88

FDI = foreign direct investment, GDP = gross domestic product, NBTT = net barter terms of trade.
Notes: *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance. Results of one-step System GMM estimation with economy and time fixed effects with cluster-robust standard errors covering 490 observations in 52 developing economies.
Source: Authors' calculations.

regional trade agreement—such as the ASEAN Free Trade Area, Central America Free Trade Agreement, or Mercosur—seems to increase pressure on developing economies' export prices, supporting the arguments and findings in Lutz and Singer (1994) that fallacy of (export) composition in developing economies might worsen their terms of trade.

Because many of the control variables lack statistical significance, we test for joint significance (Wald test) of all variables with a p-value of the initial t-statistic above 0.5. This concerns the control variables—GDP, manufacturing exports, real interest rate, and lagged deviation from the long-run growth rate—which are omitted

from the regression in the second column of Table 1. There is only a minor quantitative impact on the central variables of interest (FDI in South Asia and the rest of the world, lagged dependent variable). Since the t-statistic of the deviation from the long-run growth rate has a p-value above 0.5 in this specification, it is omitted from the regression depicted in the third column, which again has a negligible impact on our finding concerning the overall positive impact of FDI on developing economies' terms of trade with the exception of a negative relationship in South Asia.

As an additional robustness check, we test to what extent the results are driven by post-2000 observations. FDI flows were quite volatile in the mid- to late 2000s and the most dramatic decline in terms of trade in South Asia began in the late 1990s (Figure 2). Therefore, as a first step, we exclude the post-2005 and post-2000 observations. For another robustness check, we include a South Asia-specific, simple time trend in the model. In all cases, our overall results remain unaffected.[10]

Quantitatively, the estimated effects for South Asia and its differences with the rest of the developing world are economically large: a long-run coefficient of 2.1% ($\beta/[1-\varphi]$) means that a 1 percentage point increase (decrease) in the FDI stock-to-GDP ratio causes the NBTT to decrease (increase) by 2.1%. While being considerably larger in absolute magnitude than in other developing economies, FDI stocks and flows relative to GDP are lower in South Asian economies.

A. Variation between Economies

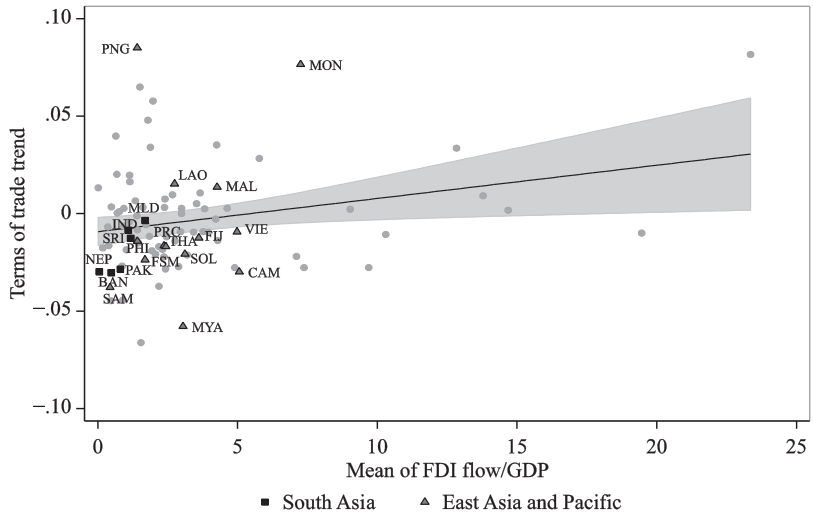
To provide further evidence of the different effect of FDI on terms of trade in South Asia compared with the rest of the world, we estimate a functionally different unconditional cross-economy model using the same dataset as above:

$$g(NBTT)_i = \alpha + \beta \times avg(FDI\ flow/GDP)_i + \epsilon_i \tag{4}$$

where g is the average annual growth rate from the beginning of the sample to the end of the sample and *avg* is the mean for each economy over the sample period. In essence, this is a between-effects estimator that does not make specific assumptions about the dynamics of the underlying process and that might seem simplistic but is intuitive to interpret and has generally shown to perform well for long-run estimations, especially in the context of parameter heterogeneity in dynamic settings (e.g., Baltagi and Griffin 1984, Pesaran and Smith 1995, Pirotte 1999, Hauk and Wacziarg 2009, Stern 2010). Although our exercise is mainly for descriptive purposes, it nevertheless reinforces the claim that South Asia is different, as the

[10]Results are available upon request. When limiting the sample to the pre-2000 observations, the decreased sample size gives rise to statistical insignificance for the South Asia-specific FDI parameter, but the size of estimated parameters stays largely unaffected, making it unlikely that the economic relationship was different between the subperiods. For the other two robustness checks, both parameters are statistically significant (at the 10% level at least) and show the expected prefix. Therefore, equality of FDI parameters between South Asia and the rest of the developing world can be rejected at the 5% level of statistical significance.

Figure 4. **NBTT versus FDI/GDP**



BAN = Bangladesh, CAM = Cambodia, FDI = foreign direct investment, FIJ = Fiji, FSM = Federated States of Micronesia, GDP = gross domestic product, IND = India, LAO = Lao People's Democratic Republic, MAL = Malaysia, MLD = Maldives, MON = Mongolia, MYA = Myanmar, NBTT = net barter terms of trade, NEP = Nepal, PAK = Pakistan, PHI = Philippines, PNG = Papua New Guinea, PRC = People's Republic of China, SAM = Samoa, SOL = Solomon Islands, SRI = Sri Lanka, THA = Thailand, VIE = Viet Nam.
Note: The figure depicts the slope of the regression coefficient β from equation (4) with corresponding standard errors and the actual observed data points for Asian economies.
Source: Wacker, K. M. Forthcoming. Do Multinationals Deteriorate Developing Economies' Export Prices? The Impact of FDI on Net Barter Terms of Trade. *World Economy*.

initial exercise identifies over-time variation within economies, while our second estimation is a correlation across economies. Figure 4 shows the upward-sloping fitted line for the whole set of developing economies, confirming a positive correlation between FDI and NBTT. The figure also includes the individual observations for South Asia (squares) and East Asia and Pacific (triangles). While there is no obviously clear pattern for East Asian economies, South Asian economies are apparently clustered below the regression line β, indicating that their terms of trade development would benefit less from FDI than the overall sample of developing economies.

III. Why Is the Effect of Foreign Direct Investment on Terms of Trade Different in South Asia?

As we argued at the beginning of the previous section, there are different channels through which FDI may impact terms of trade, and these impacts may operate in opposite directions. In order to understand the negative impact of FDI on terms of trade in South Asia, in contrast to all other developing regions, it is instructive to reconcile the potentially most important channels in more detail.

Table 2. **Different Coefficients for FDI Impacts for Different Subsamples**

	Estimated Parameter	Standard Error of Parameter	F-stat (d.f.) (p-val)
Education I: Percentage of primary school completed			
Below sample median	0.00064	0.00070	1.74 (1, 43)
Above sample median	0.00176	0.00067	(0.1944)
Education II: Years of schooling			
Below sample median	−0.00072	0.00097	6.78 (1, 43)
Above sample median	0.00165	0.00059	(0.0126)

FDI = foreign direct investment.
Note: The table depicts the different impacts the regression coefficient β from Equation (1) has for different subsamples of economies.
Source: Wacker, K. M. Forthcoming. Do Multinationals Deteriorate Developing Economies' Export Prices? The Impact of FDI on Net Barter Terms of Trade. *World Economy*.

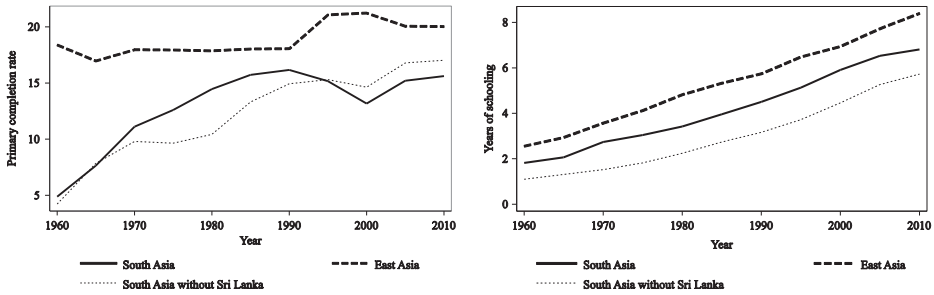
Our key argument concerns the role of product upgrading that can take place either directly through FDI or through interindustry and intra-industry spillovers (e.g., Javorcik 2004, Havranek and Irsova 2011, Harding and Javorcik 2012). If this effect is large, it will lead to an increase in export unit values and terms of trade, as the latter reflect (at least partially) such quality upgrading effects (e.g., Lipsey 1994, Schott 2004, Hummels and Klenow 2005, Silver 2010).

A. The Role of Education

For this effect to be prevalent, however, a sufficient level of human capital in the host economy is crucial. This is demonstrated in Table 2, which shows that the effect of FDI on terms of trade is particularly positive in economies with above-median levels of education. The underlying regression is the model in Equation (1) but the parameter estimate for the impact of FDI, β, is allowed to vary between economies above and below the sample median value in educational attainment. The results indicate that economies with a higher percentage of completed primary schooling obtain stronger positive effects of FDI on terms of trade (although the difference is not statistically significant). Furthermore, economies with below-median years of schooling suffer from a negative impact of FDI on terms of trade, while those with more years of schooling experience a strong positive impact. The difference between these two types of economies is statistically significant at the 5% level as shown by the results of an F-test reported in the rightmost column of Table 2. This is in line with Borensztein, De Gregorio, and Lee (1998), who find that FDI flows to 69 developing economies after 1970 had a positive impact on productivity only when the host economy had reached a minimum level of human capital development. Thus, our finding supports the view that the positive impact of FDI on terms of trade is either fostered by or requires a threshold level of education.

Educational levels have historically been very different between South Asia and East Asia, with attainment levels in South Asia being very low by international

Figure 5. **Educational Attainment in East Asia versus South Asia, 1960–2010**



Note: Values computed as unweighted averages for Bangladesh, India, Pakistan, and Sri Lanka in South Asia; and for the People's Republic of China, Indonesia, Malaysia, the Philippines, and Thailand in East Asia.
Source: Barro, R., and J.–W. Lee. 2013. A New Data Set of Educational Attainment in the World, 1950–2010. *Journal of Development Economics* 104 (2013): 184–98.

standards. This is depicted in Figure 5 showing the (unweighted) average primary completion rate of 15-year olds (left panel) and years of schooling (right panel). South Asia has consistently trailed East Asia in terms of educational attainment over the past 50 years. The disparities between the two regions become even more pronounced if Sri Lanka is taken out of the sample. Less than 10% of 15-year olds in India and Pakistan and only 15.8% in Bangladesh had completed primary school in 1980. Although the gap in primary completion has narrowed over the past decade, it takes time for these changes to translate into a better-educated workforce. East Asia could thus rely on a broader skills base when its economies opened up, allowing for more product upgrading through FDI, which requires an educated workforce. This precondition was not present in South Asia, thereby reducing the positive effects of FDI in South Asia, which might explain the different impact that FDI has had on terms of trade in South Asian economies.

B. Pricing Power and Market Share

Our argument of a skills shortage as an impediment to moving toward higher segments of the value chain relates to the recent literature on export composition (Hausmann, Hwang, and Rodrik 2007) and the traditional argument in the literature on the Prebisch–Singer hypothesis that industrialized and developing economies produce different types of products (e.g., Sarkar and Singer 1991). As lower-quality, less skill-intensive products are more reproducible and more homogenous, their exporters will possess less market and pricing power, resulting in a terms of trade decline, as outlined by structuralist contributions to the Prebisch–Singer hypothesis (e.g., Emmanuel [1969] 1972, Raffer 1987).

Even though FDI might still considerably increase productivity in cases where the low-skill export sector expands, the mode of FDI-led world market integration and associated terms-of-trade effects are very different, as productivity increases

translate into lower costs and export prices as opposed to upgrading and pricing power effects. We call the former a price competitiveness approach to world market integration and the latter a quality competitiveness approach.

C. Types of Foreign Direct Investment and Its Relation to Human Capital

An additional potential explanation for the differing terms-of-trade effects of FDI is that such investment can come in the form of horizontal FDI, mainly substituting for trade by domestically serving host markets, and vertical FDI, essentially slicing up the value chain and producing upstream goods in the developing host economy.

The key motive for vertical FDI is a multinational firm's holdup problem: if a vertically integrated corporation in an industrialized economy faces an imperfect input good (upstream) market in a developing economy, the upstream firm will produce too low a quantity in order to maximize profits. The (multinational) downstream firm will have an incentive to enter the upstream market because marginal production costs are lower than the price it actually pays for the input. Leaving aside the problem of transfer pricing, the entry of a foreign firm into the upstream market will increase the produced quantity and thereby lower the price for the upstream good. As quantity effects are not considered in NBTT, this transnational engagement will, ceteris paribus, lead to a fall in the upstream (developing) economy's terms of trade (Wacker 2011).

The literature on FDI and multinationals highlights the role of differences in human capital endowment as an important determinant of vertical versus horizontal FDI flows. More precisely, Blonigen, Davies, and Head (2003) find that absolute skills differences between the parent and host economies of FDI reduce horizontal FDI, while Davies (2008) shows that vertical FDI increases with a skills difference between the parent and the host. On the other hand, a large host economy will induce more horizontal FDI as the large market size will compensate for high entry costs.

Given that South Asian economies historically have low-skill labor forces (and therefore considerable human capital differences with FDI home economies), and are moderately attractive for market-seeking horizontal FDI (with the exception of India), most FDI in the region might be driven by vertical motives, thus potentially leading to negative terms-of-trade effects.

In the next section, we empirically elaborate on these economic arguments, using descriptive data for four Asian economies.

IV. Foreign Direct Investment and World Market Integration in Four Asian Economies: An Empirical Investigation

Very few economies publish FDI data with a comprehensive industry-level breakdown, especially in developing and emerging economies, which makes it

difficult to provide convincing evidence about the different effects of FDI on terms of trade.[11] We therefore rely on the analysis of two East Asian and two South Asian economies for which data were available through national sources while remaining cognizant of the limitations of this approach. Furthermore, we consult trade data published by the World Trade Organization (WTO).[12] Constructing export profiles for all economies in our sample allows us to identify the most competitive sectors, measured by the size of exports relative to worldwide exports in the respective product group, and observe changes over time.[13] Combining both yields a detailed picture of each economy's strengths. It also allows us to draw conclusions about the specific role of FDI in an economy and its relevance for increases in exports. In our South Asia group, sectoral FDI data are available for Bangladesh and Pakistan.[14] In our East Asia group, we take a closer look at Malaysia and Thailand.

A. Export Composition and Foreign Direct Investment in Two Sample South Asian Economies

FDI flows into Pakistan have been relatively diversified. The most relevant sector is transport and communications, which accounted for 26% of cumulative FDI inflows in 2000–2012. Finance, food, and the oil and gas sectors saw considerable FDI inflows as well. The textiles sector has received little to no FDI inflows, although it ranks prominently among exports. The manufacture of textile articles and grain mill products are Pakistan's most successful exports; there has been relatively little change in the composition of the economy's top 10 list of exported goods over the last decade (see Appendix for more detail). The most significant new entrant to the list of the top 10 exported goods over this period was cement, lime, and plaster. Bangladesh has attracted relatively little FDI overall. However, the textile and garment sector is on the rise and accounted for 24% of the total FDI stock in 2011, which is a similar share to that of the electricity, gas, and water sector.

[11] Even if data were available for all economies in our regions of interest, considerable issues of measurement and comparability would remain. Sectoral classifications vary from source to source, while some economies publish actual realized FDI and others publish all FDI that has been approved by the relevant authorities. There is no publicly accessible dataset that addresses all of these concerns. The most advanced approach is the investment map constructed by the International Trade Center (ITC). But since it does not date back far enough in time for most economies, we chose for our analysis to primary rely on national data sources where a historical sectoral breakdown was available. However, we supplement these national data by double-checking with ITC data to the extent possible.

[12] More precisely, we analyze exports classified under ISIC Revision 3 HS 1998/92 (World Integrated Trade Solution) to ease the comparisons with the sectoral FDI data. For each economy, we compare the earliest to the latest available period. Top 10 lists of the products with the highest share in the world market are calculated at the 4-digit level. These lists are available in the Appendix.

[13] For Pakistan, the earliest available trade data in our chosen nomenclature is 2003; the latest is 2014. This rather short and recent observation period explains why the changes remain small, but does not affect our other conclusions. For Bangladesh, the earliest data are taken from 1989. The latest available data is from 2011. Malaysia and Thailand both have 1989 as the year in which the earliest data are available and 2014 as the latest.

[14] In Bangladesh, the central bank surveys foreign investors periodically and disaggregates FDI inflows by sector, component type, and economy of origin. In Pakistan, the Board of Investment publishes sector-wise FDI inflows. In both economies, the data collection is generally presented according to the financial year, which runs from 1 July until 30 June. In Malaysia and Thailand, sector-disaggregated FDI data are made available by the central banks.

FDI in the finance sector ranked third and accounted for 20% of the inward stock, according to ITC data.[15] Similar to Pakistan, the export profile of Bangladesh is very much focused on textiles and textile-related products (see Appendix for more detail). With the top four exported goods categories all being different forms of textiles, the economy has focused on low-cost manufacturing as a means of export-led development. The degree of specialization is very high: the top four product categories account for over 85% of all Bangladeshi exports. The most significant change in the list of leading exported goods between 1989 and 2011 was that a new entrant made it to the second spot on the list. A form of textile products that barely registered among the economy's exports in 1989 with a 0.8% share accounted for 30.9% of the economy's exports in 2011.

Bangladesh can be seen as a poster child of the price competitiveness approach, in which FDI in tradable sectors flows into low-quality, highly-competitive product segments. Nevertheless, considering the relatively poor FDI performance of textiles compared to the sector's total exports, the role of domestic companies should not be understated. At the same time, this does not conflict with our claim that FDI helps shape the export structure of the entire economy.

B. Comparisons with Two Sample East Asian Economies

In our East Asian examples, the story is quite different as higher-value manufacturing products rank more prominently in the export structure. In Malaysia, this coincides with a high level of FDI inflows into manufacturing in the 1990s that gradually shifted into the tertiary sector in the 2000s. According to official data (Bank Negara Malaysia 2009), cumulative net FDI inflows in manufacturing amounted to 63% of FDI in 1990–1999 before falling to 41% in 2000–2009. This difference was added to the share of FDI flows into the services sectors, primarily the finance sector, which is consistent with Malaysia's position as an important regional financial hub. The trade profile reveals that the most successful Malaysian products are electronic components and machines, crude and refined petroleum products, and vegetable and animal oils and fats (see Appendix for more detail). Some higher-value products were among the top 10 exports in 2014, including transmitters and office, accounting, and computing machinery.

For Thailand, the relation between sectoral FDI inflows and export dynamics is even more striking. Cumulative FDI inflows in 2005–2011 reveal that almost 49% of FDI targeted manufacturing, with financial services being the second most important

[15]The exact sizes of different sectors differ by data source (e.g., due to definitions of FDI, differences between registered and realized investments, and partly due to different sector classifications) and examined time period (especially due to large-scale, lumpy FDI in individual sectors). The relative importance of the textile and garment sector, however, is beyond doubt, especially within the manufacturing and tradable sector (see, for example, Tables VI and IX in Bangladesh Bank 2014) and when taking into account that the sector is very labor-intensive (i.e., investment data tend to underestimate its relevance).

sector at 21%. A further disaggregation of FDI in the manufacturing sector reveals that the largest recipient product groups were motor vehicles, electrical equipment, electronics and optics, and plastics. These sectors, especially motor vehicles and associated parts and components, also had the strongest export performances between 1989 and 2014, often with significant changes in world market shares during the review period. Many of the higher-value manufactured exports were insignificant in the economy's export profile in 1989 but were among the top 10 exported goods in 2014 (see Appendix for more detail). This is clear evidence that FDI flows have gone into higher segments of the value chain in Thailand than in Bangladesh, for example. Furthermore, these FDI flows have possibly helped upgrade Thailand's export portfolio. Apart from this upward movement along the value chain, we also find evidence that FDI is used as a bridgehead into foreign markets: 37% of FDI inflows in the review period were of Japanese origin. As Nguyen (2013) highlights, these Japanese FDI flows have been export- and long-run oriented, and clustered in the electronics value chain. Japanese FDI flows have recently moved to other East Asian economies as well, such as Indonesia and Viet Nam, the latter of which has been explicitly targeting export-oriented FDI.

C. The Larger Picture

The trade profiles for all four economies in our sample of developing Asia show a strong trend of upward movement along individual value chains. However, the prospects of these value chains might differ substantially since some offer more promising outlooks than others. For example, the textiles value chain remains rather competitive, while the electronics industry provides more space for product differentiation and quality- and competitiveness-led strategies. Accordingly, Pakistan and Bangladesh have each only managed to obtain modest market shares of up to 6.2% in certain product groups, mostly low-skill textile manufacturing. Some upticks in market shares have been recorded in recent years. Malaysia, on the other hand, attained considerable market shares in higher-skill products (e.g., 7.8% in electronic valves, tubes, and other components; and up to 12.8% for some higher-value commodity processing), which is an impressive performance considering it is the smallest in terms of population among our four sample economies. In Thailand, which has the second smallest population among the sample group, the situation is somewhat veiled by the exceptional dynamics in the export sector. For example, until 2011, each of Thailand's four top export products held a world market share of more than 10%, while the remaining top 10 export products held a world market share of at least 5%. Only 3 years later, the picture had changed, with moves into higher-skill and -value manufactures at the expense of market shares. However, Thailand still holds significant world market shares in products that are not on its top 10 export list (e.g., a 10.8% share for sugar, which ranks 24th among exported goods).

Looking at other East Asian economies, the dominant impact of the PRC in trade becomes apparent. In 2014, the PRC held export shares of over 40% in all 10 of its leading export categories and shares of over 25% in a total of 38 export categories. The export portfolio is well-rounded in general. The economy has also achieved the remarkable feat of steadily reducing the share of its textile exports while simultaneously increasing its world market share. To put this into perspective, the PRC has achieved a 45% share of world exports in the market segment of wearing apparel except fur apparel, which at the same time only accounted for about 6% of its domestic exports in 2014. This also happens to be the most important export segment for Bangladesh and the second most important segment for Pakistan, neither of which achieved a world market share of more than 4% in this category despite their narrow specialization.

Indonesia holds considerable shares in some export market segments as well. The economy has intensified the export of hard coal and lignite since 2009, accounting for world export shares that exceed 20% and 80%, respectively. The Philippines lags behind in this aspect but has managed to develop export market power in at least one category, carpentry and joinery, accounting for over 18% of world exports in 2014. India again offers a somewhat diverse picture with dynamic changes in recent years. Historically, jewelry has been India's most important export in terms of world share, reaching 28% in 2011. However, the sector's export share has since been in decline, with a world market share of 16% in 2014. In the meantime, the manufacture of grain mill products rose from a world market share of 10% in 2011 to become India's leading export with a 20% share in 2014. Finally, Sri Lanka's most important export is textiles, comprising 36% of all exports, yet its textile exports only comprise a world market share of 1.2%. No other Sri Lankan export exceeds this level of world export share.

Aside from the lower-skill and -value exports and small world market shares in South Asia, another difference with East Asia is the high concentration of exports among just a few products. Bangladesh provides the most striking example with almost 80% of exports concentrated in two product groups, neither of which reached a world market share of more than 6.2%, and over 95% of exports concentrated in the top 10 product groups. In Pakistan, the top two and top 10 product groups account for 37% and 76% of exports, respectively. In Malaysia, the top two and top 10 products account for 30% and 65% of exports, respectively, even though Malaysia has only about one-fifth of either Pakistan's or Bangladesh's population and its exports could thus be expected to be more specialized. The picture is even more striking in Thailand, with the respective shares being 16% and 46%. In general, it seems that East Asian economies managed to conquer more markets and niches, especially in higher-value products, than South Asian economies, even without as much export specialization.[16] This might potentially indicate that South Asia is in a less favorable

[16]This general picture does not apply to India to the same extent.

Table 3. **Export Complexity of Investigated Economies, 2012**

Rank	Economy	ECI Value
24	Malaysia	0.99
33	Thailand	0.88
91	Pakistan	−0.34
119	Bangladesh	−0.92

Notes: The Economic Complexity Index (ECI) is a measure of an economy's export diversity and sophistication.
Source: The Observatory of Economic Complexity. Economic Complexity Index. http://atlas.media.mit.edu/en/rankings/country/2012/

position in the product space in which spillovers and complementarities between products are less relevant (Hidalgo et al. 2007).

FDI inflows have been more concentrated in East Asian economies, about half of which in Malaysia and Thailand have targeted the manufacturing sector. This suggests that FDI might be conducive to movements in the product space in general, and upward movements more specifically, potentially supporting pricing power and associated terms-of-trade effects. In South Asia, FDI flows were more scattered across sectors, with services (communications, finance, and transport) and oil and gas receiving considerable shares. The fact that one-fourth of FDI in Bangladesh flowed into textiles is consistent with the shape of the economy's export structure—the top four exported goods are textile-related and account for 85% of exports—but despite this enormous specialization, the economy was not able to develop large market shares and associated pricing power, potentially because the sector is characterized by homogenous products with low-skill content in which competition is fierce.

The considerably higher export sophistication of Malaysia and Thailand compared with Pakistan and Bangladesh is also mimicked in the Massachusetts Institute of Technology's Economic Complexity Index, which is presented in Table 3. The index takes into account the ubiquity and diversification of an economy's export structure. That is, economies that export several different products obtain a high diversification measure. But as it is easier to produce products that are ubiquitous, these products get less attention in the overall index. The measure is thus highly informative for our analysis as it shows whether economies have the capability to produce a diversified export portfolio and manage to be highly competitive in certain product niches that are less occupied by other economies. It is clear from Table 3 that this applies considerably more to East Asian economies than their South Asian counterparts—a general picture that holds beyond our four-economy example.[17]

[17]The rankings of other East Asian economies include the PRC (22), the Philippines (46), and Indonesia (69). The rankings of other South Asian economies include India (54) and Sri Lanka (86).

Questions arising from our quantitative assessment of FDI inflows and export specialization are to what extent East Asia's focus on higher-skill products is preferable to South Asia's world market integration strategy, and to what extent the latter can be seen as a temporary or transitory phenomenon in the development process. We discuss these issues along with policy considerations in the next section.

V. Policy Discussion

We have argued that South Asian and East Asian economies followed different strategies of world market integration in the sense that the latter achieved considerable upward movement along the value chain (quality competitiveness), while the former conquered foreign markets by stronger reliance on price competitiveness. We have further argued that these integration strategies were in line with the respective factor endowments (i.e., a higher-skilled labor force in East Asia) and broadly in line with patterns of FDI inflows that potentially helped shape the export structure and mode of world market integration.

Is either of the two different world market integration strategies more favorable from a development perspective? When looking at some basic macroeconomic indicators, South Asia and East Asia have both achieved impressive development progress. East Asian economies have achieved average annual growth of 7.1% since 1990, while South Asian economies have achieved average growth of 4.4% per year.[18] Hence, both subregions outperformed (by more than one standard deviation) the 2% per year per capita historical growth average that Summers and Pritchett (2014) calculated for all economies since 1950. Meanwhile, extreme poverty in East Asia declined from 78% of the population in 1981 to 8% in 2011. While progress in reducing extreme poverty in South Asia has also been impressive, the gains have been less dramatic with the ratio falling from 61% to 25% over the same period.[19]

These crude numbers suggest that economic development has been more rapid in East Asia, yet our main argument holds that these economies started out with a considerably higher human capital base and thus more favorable initial conditions. Furthermore, one could argue that South Asia is simply at an earlier stage of the development path. For example, the PRC initially also integrated into the world economy via low-end production goods such as clothing, footwear, and furniture, which all appear to have peaked at 40%–50% of total imports in the United States and European Union as the PRC moves toward higher rungs of the production ladder (Nguyen 2013).

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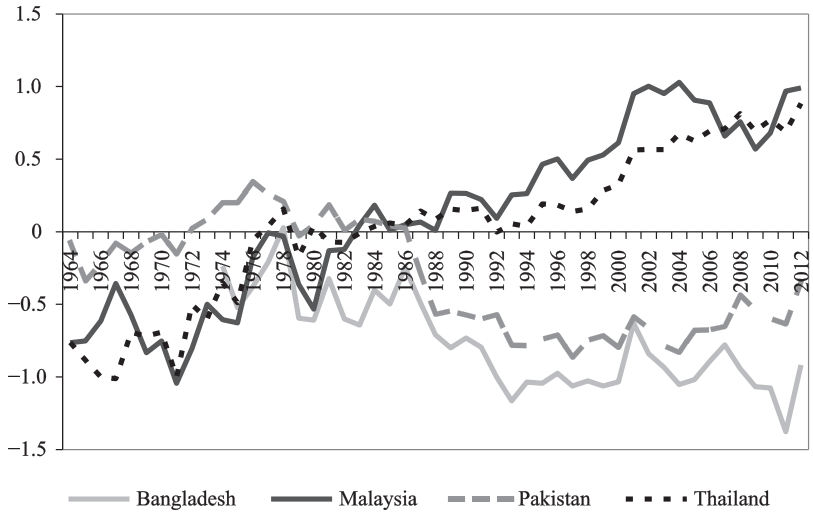
[18] Growth of real GDP per capita in purchasing power parity terms, calculated based on the Word Bank's *World Development Indicators*. East Asia only includes developing economies.

[19] Following World Bank standards, extreme poverty is defined as the population living on less than $1.25 per day in purchasing power parity terms.

Figure 6. **Export Complexity over Time**



Notes: The Economic Complexity Index (ECI) is a measure of an economy's export diversity and sophistication.
Source: The Observatory of Economic Complexity. Economic Complexity Index. http://atlas.media.mit.edu/en/rankings/country/2012/

A. Is South Asia Simply at an Earlier Stage of the Development Path?

In our view, there are two key reasons casting doubt on the possibility that South Asian economies are simply at an earlier stage of an established development path that will ultimately lead them to the same destination as their East Asian peers.

First, if South Asian economies are increasingly upgrading their export structure, we should find such a trend in the data. However, as the development of the Economic Complexity Index over time suggests (Figure 6), this is not the case: the index has stagnated over the last 2 decades for our South Asian sample economies (Bangladesh and Pakistan), while it has continuously increased since the 1960s for our East Asian sample economies (Malaysia and Thailand). This pattern seems consistent with path dependence in production structures as suggested by the product space literature (Hidalgo et al. 2007).

Second, upgrading the human capital base at later stages of world market integration becomes increasingly difficult as the increased demand for tradables will also increase wage pressures for civil servants such as teachers despite unchanged productivity (see Sen 1999). Sen has emphasized how important pursuing human resource development before embarking on wider development goals has historically been for East Asian economies such as Meiji, Japan; the Republic of Korea; and Taipei,China.

B. Or Did East Asian Economies Kick Away the Ladder for South Asia?

Finally, there is also the possibility that East Asian economies kicked away the upgrading ladder for their South Asian peers: when East Asian economies embarked on their export-oriented development strategies, markets for many higher-value products were still available and they could integrate via a quality competitiveness strategy. Supported by FDI, they were able to occupy upper segments of the value chain and enjoy market power to achieve favorable export prices and terms of trade in these product segments. The opposite is true for South Asian economies, which have had to integrate via more competitive markets, generally through price competition.

This interpretation raises the question to what extent less developed economies can fully choose their own growth strategy when integrating more deeply into the world economy. As more economies move up the ladder of product development, an increasing number of the higher rungs become occupied.[20] In our view, this casts some doubt on the extent to which successful development strategies in open economies of the past can be copied by other economies, and about the extent to which South–South cooperation can be beneficial to lower-income economies.

C. What Are the Policy Lessons?

Do our findings about the South Asia-specific effects of FDI on terms of trade and the role of human capital in this context imply that economies' world market integration strategies and development pathways are shaped by geography and educational history while not leaving much scope for policy? In our view, there is no need for such a fatalistic interpretation of the evidence.

For starters, the world market integration strategy of South Asia relative to East Asia and other developing economies is not necessarily determined by geography. It rather accidentally coincides with the World Bank's regional classifications and actually represents differing underlying fundamentals. And as the literature on export upgrading suggests, such fundamentals, like factor endowments and institutions, play an important role for specialization patterns but do not uniquely determine what an economy can and will export.

As the literature emphasizes, fostering an environment that promotes entrepreneurship and investment in new activities is critical to creating information spillovers for higher-potential sectors (see Rodrik 2004). Active FDI attraction, e.g. through investment promotion agencies, can be part of such a policy (Harding and Javorcik 2011, 2012). However, as our analysis suggests, the sectoral distribution of FDI matters in this context. Our above reasoning and previous results in the

[20]This is consistent with the empirical finding of Harding and Javorcik (2012) that FDI does not make developing economies' export structure more similar to that of higher-income economies, and with Rodrik's (2014) argument of premature (de-)industrialization, which pointed out that industrialization in low-income economies is running out of steam considerably earlier than has traditionally been the case.

literature (Borensztein, De Gregorio, and Lee 1998) further highlight the relevance of improving the human capital stock through education at early stages of the development process.

Finally, while our econometric results in section II can in principle be interpreted as causal, they are conditional on country-specific effects and associated initial conditions. In fact, the South Asia-specific (and education-specific) FDI effects highlight how these initial conditions matter. Accordingly, one should not draw the policy conclusion that preventing FDI inflows would have been beneficial for South Asian economies. First, falling terms of trade might simply reflect productivity increases in homogenous products in those economies. Second, the interesting policy question in our view is not whether FDI inflows should be banned but to what extent initial conditions and capabilities can be changed by policy.

VI. Conclusions

In this paper, we replicated and substantiated earlier findings that FDI has had a detrimental effect on terms of trade in South Asia, as opposed to the positive terms-of-trade effect it has had in the rest of the developing world. As this relationship seems to depend on the level of human capital, and building on the observation that education levels in South Asia are considerably lower than in East Asia and many other regions of the developing world, we provided an explanation for this South Asia-specific effect.

We have argued and supported with descriptive evidence that, by building on a high human capital base, East Asia managed to considerably upgrade its export structure. Its product portfolio is now more complex and diversified, and these economies have managed to acquire considerable world market shares in certain higher-quality niches such as electronic components, motor vehicles, and office machinery, as well as higher-value commodity processing. These niches largely corresponded with the structure of earlier FDI inflows. Given the market power these economies could develop in their product categories, they were able to integrate into the global economy using a quality competitiveness approach that was accompanied by favorable terms of trade developments.

In contrast to East Asia's experience, South Asian economies found several of these high-potential product niches already occupied once they increasingly industrialized and integrated into the world economy. In line with their much lower human capital endowment, these economies specialized in lower-skill goods, most notably textiles. In Bangladesh, this was accompanied by significant FDI inflows into the textile sector, while FDI inflows into our other example economy, Pakistan, were spread across different sectors. Generally, South Asian exports are less complex and less diversified than East Asian exports, and South Asian economies have not managed to acquire large global market shares. Given the associated homogeneity

and ubiquity of their export products, South Asian economies have not developed much export pricing power and have had to integrate into the world economy through a price competitiveness approach that corresponded with declining terms of trade.

Our contribution thus relates to recent approaches about export upgrading, product space, and the role of FDI in this process (Hausmann, Hwang, and Rodrik 2007; Harding and Javorcik 2012). However, it also builds a bridge to earlier contributions in the development literature that interpreted declining terms of trade in developing economies as a feature of the specific goods they produce (Sarkar and Singer 1991), and saw this export structure being largely shaped by foreign investment (Singer 1950).

Given the relevant interactions between initial human capital endowment, FDI, and export structure that we highlight in this paper, we think that future studies on the most appropriate design and sequencing of policy reforms—such as skills upgrading, tax reform, regulation, financial deepening, and investment promotion—would be highly beneficial for effective policy making, especially in economies starting out from low levels of development and education. In this context, we would like to emphasize that our results can only help explain the specific interaction of FDI, export prices, and world market integration in Asia but cannot provide clear policy guidance as to whether economies with low education levels should foster FDI and exports in low-skill sectors or put more emphasis on the prior or simultaneous development of human capital and capabilities.

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APPENDIX: Export Data for the 2 × 2 Economy Investigation

PAKISTAN	2003			2014		
Product Code and Description	**Rank**	**% of Economy Exports**	**% of World Exports**	**Rank**	**% of Economy Exports**	**% of World Exports**
1711 - Preparation and spinning of textile fiber; weaving of textiles	1	26.2%	3.8%	1	20.2%	4.3%
1810 - Manufacture of wearing apparel, except fur apparel	2	21.0%	1.5%	2	17.3%	1.3%
1721 - Manufacture of made-up textile articles, except apparel	3	20.0%	9.0%	3	16.1%	6.0%
1531 - Manufacture of grain mill products	4	5.7%	4.9%	4	9.8%	6.1%
1730 - Manufacture of knitted and crocheted fabrics and articles	6	2.4%	0.4%	5	3.2%	0.7%
1911 - Tanning and dressing of leather	7	2.0%	1.5%	6	2.2%	2.4%
2694 - Manufacture of cement, lime, and plaster	32	0.2%	0.3%	7	2.1%	4.9%
0113 - Growing of fruit, nuts, beverage, and spice crops	14	0.9%	0.2%	8	2.0%	0.4%
2320 - Manufacture of refined petroleum products	8	2.0%	0.1%	9	1.7%	0.1%
0111 - Growing of cereals and other crops n.e.c.	10	1.4%	0.2%	10	1.5%	0.2%
3693 - Manufacture of sports goods	5	2.8%	2.6%	11	1.5%	1.4%
1722 - Manufacture of carpets and rugs	9	1.9%	2.4%	24	0.5%	0.8%
Top 10 export goods' share of total economy exports		85.4%			76.3%	

BANGLADESH	1989			2011		
Product Code and Description	Rank	% of Economy Exports	% of World Exports	Rank	% of Economy Exports	% of World Exports
1810 - Manufacture of wearing apparel, except fur apparel	1	33.5%	1.6%	1	48.3%	4.0%
1730 - Manufacture of knitted and crocheted fabrics and articles	12	0.8%	0.1%	2	30.9%	6.2%
1721 - Manufacture of made-up textile articles, except apparel	3	11.2%	4.6%	3	4.3%	1.8%
1711 - Preparation and spinning of textile fiber; weaving of textiles	5	10.7%	0.6%	4	3.3%	0.7%
1512 - Processing and preserving of fish and fish products	2	12.4%	1.4%	5	2.4%	0.6%
0111 - Growing of cereals and other crops n.e.c.	6	6.8%	0.4%	6	1.6%	0.1%
1920 - Manufacture of footwear	32	0.0%	0.0%	7	1.4%	0.3%
1911 - Tanning and dressing of leather	4	10.7%	5.3%	8	1.3%	1.5%
2320 - Manufacture of refined petroleum products	60	0.0%	0.2%	9	1.0%	0.0%
9999 - Goods not elsewhere classified	18	0.2%	0.0%	10	0.8%	0.1%
2412 - Manufacture of fertilizers and nitrogen compounds	7	3.7%	1.3%	13	0.3%	0.1%
1549 - Manufacture of other food products n.e.c.	8	1.8%	0.7%	39	0.0%	0.0%
2924 - Manufacture of machinery for mining, quarrying, and construction	9	1.7%	0.2%	58	0.0%	0.0%
0122 - Other animal farming; production of animal products n.e.c.	10	1.6%	1.2%	94	0.0%	0.0%
Top 10 export goods' share of total economy exports		94.2%			95.4%	

MALAYSIA	1989			2014		
Product Code and Description	**Rank**	**% of Economy Exports**	**% of World Exports**	**Rank**	**% of Economy Exports**	**% of World Exports**
3210 - Manufacture of electronic valves and tubes and other electronic components	1	15.7%	10.6%	1	17.9%	7.8%
1110 - Extraction of crude petroleum and natural gas	2	14.8%	16.8%	2	12.9%	3.6%
2320 - Manufacture of refined petroleum products	11	1.5%	4.2%	3	8.7%	2.7%
1514 - Manufacture of vegetable and animal oils and fats	3	9.1%	25.5%	4	6.9%	12.8%
3000 - Manufacture of office, accounting, and computing machinery	18	1.0%	0.5%	5	5.9%	2.9%
3230 - Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods	4	8.3%	5.6%	6	3.2%	3.4%
2411 - Manufacture of basic chemicals, except fertilizers and nitrogen compounds	17	1.0%	0.7%	7	2.9%	1.7%
2720 - Manufacture of basic precious and nonferrous metals	9	2.3%	1.6%	8	2.5%	1.0%
2519 - Manufacture of other rubber products	10	1.6%	9.4%	9	2.1%	8.0%
3220 - Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy	20	0.9%	1.5%	10	2.0%	1.2%
0200 - Forestry, logging, and related service activities	5	6.5%	52.4%	45	0.3%	3.4%
0111 - Growing of cereals and other crops n.e.c.	6	5.9%	7.0%	28	0.6%	0.6%
2010 - Sawmilling and planing of wood	7	5.1%	12.4%	32	0.5%	2.6%
1810 - Manufacture of wearing apparel, except fur apparel	8	2.8%	2.6%	31	0.5%	0.3%
Top 10 export goods' share of total economy exports		72.2%			65.2%	

THAILAND	1989			2014		
Product Code and Description	Rank	% of Economy Exports	% of World Exports	Rank	% of Economy Exports	% of World Exports
3410 - Manufacture of motor vehicles	44	0.3%	0.0%	1	8.2%	2.1%
3000 - Manufacture of office, accounting, and computing machinery	6	5.4%	2.2%	2	8.0%	3.7%
2320 - Manufacture of refined petroleum products	133	0.3%	0.6%	3	4.5%	1.3%
3210 - Manufacture of electronic valves and tubes and other electronic components	8	3.9%	2.1%	4	4.4%	1.9%
2413 - Manufacture of plastics in primary forms and of synthetic rubber	47	0.3%	0.3%	5	4.3%	3.9%
2411 - Manufacture of basic chemicals, except fertilizers and nitrogen compounds	50	0.3%	0.1%	6	3.6%	2.0%
0111 - Growing of cereals and other crops n.e.c.	1	11.0%	10.3%	7	3.5%	3.5%
3430 - Manufacture of parts and accessories for motor vehicles and their engines	59	0.2%	0.1%	8	3.4%	2.0%
3230 - Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods	11	2.2%	1.2%	9	2.9%	3.0%
3691 - Manufacture of jewelry and related articles	5	5.6%	12.2%	10	2.9%	3.0%
1810 - Manufacture of wearing apparel, except fur apparel	2	10.2%	7.5%	30	1.0%	0.7%
1512 - Processing and preserving of fish and fish products	3	9.6%	15.8%	11	2.8%	6.7%
1531 - Manufacture of grain mill products	4	9.4%	59.5%	13	2.5%	14.6%
1542 - Manufacture of sugar	7	3.9%	27.6%	24	1.2%	10.8%
1711 - Preparation and spinning of textile fiber; weaving of textiles	9	3.0%	2.6%	35	0.8%	1.5%
1920 - Manufacture of footwear	10	2.7%	5.1%	57	0.3%	0.6%
Top 10 export goods' share of total economy exports		64.7%			45.6%	

n.e.c. = not elsewhere classified.
Source: UN Comtrade, ISIC Revision 3 HS 1988/92 (accessed through World Integrated Trade Solution).

Why Do Economies Enter into Preferential Agreements on Trade in Services? Assessing the Potential for Negotiated Regulatory Convergence in Asian Services Markets[+]

Pierre Sauvé and Anirudh Shingal[*]

More than one-third of the World Trade Organization-notified services trade agreements that were in effect between January 2008 and August 2015 involved at least one South or Southeast Asian trading partner. Drawing on Baier and Bergstrand's (2004) determinants of preferential trade agreements and using the World Bank's database on the restrictiveness of domestic services regimes (Borchert, Gootiiz, and Mattoo 2012), we examine the potential for negotiated regulatory convergence in Asian services markets. Our results suggest that Asian economies with high levels of preexisting bilateral merchandise trade and wide differences in services regulatory frameworks are more likely candidates for services trade agreement formation. Such results lend support to the hypothesis that the heightened "servicification" of production generates demand for the lowered services input costs resulting from negotiated market openings.

Keywords: Asia, preferential trade agreements, regulation, regulatory convergence, services trade
JEL codes: F10, F13, F15

I. Introduction

One of the striking features of trade diplomacy in recent years has been the seemingly unstoppable march of preferential trade liberalization and rule-making (Kawai and Wignajara 2010). Such a trend now extends to services, particularly in the Asia-Pacific region (Chanda 2011, PECC and ADBI 2011, Shepherd and Pasadilla 2012). Of the 81 preferential trade agreements (PTAs) that entered in force prior to January 2000, 73 (90%) featured provisions dealing exclusively with trade in goods. Between January 2000 and August 2015, 124 of the 194 PTAs that

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[+]This paper is the outcome of a successful call for proposals by the Asian International Economists Network for a conference on Trade Competitiveness in a World of Rapid Change: What Challenges and Opportunities for Asian Economies hosted by the Asian Development Bank in Manila on 22 March 2013. The authors would like to thank the conference participants, Martin Roy, the managing editor, and two anonymous referees for helpful comments on previous versions of this paper. The usual disclaimer applies.

entered into force also included provisions on services trade. The above trend signals the heightened importance of services trade in general, the growing need among economies to place such trade on a firmer institutional and rule-making footing, and the attractiveness of doing so on an expedited basis via preferential negotiating platforms (Sauvé and Shingal 2011). Interestingly, more than one-third (28) of the 78 World Trade Organization (WTO)-notified services trade agreements (STAs) that were in effect between January 2008 and August 2015 involved at least one South or Southeast Asian trading partner.

Unlike trade in goods, where the removal of border barriers retains significant negotiating traction, domestic regulation is the sole currency of negotiations in services trade (Mattoo and Sauvé 2010). The importance and potentially trade- and investment-inhibiting impact of domestic regulation on service sector performance has received significant attention in policy research circles (Kox and Nordås 2007, 2009). However, less well understood and investigated has been the question of whether certain economies are more likely candidates for negotiated regulatory convergence from a services trade perspective. Simply put, are economies that display greater ex ante regulatory convergence more likely candidates for deeper integration agreements in services markets? Is the demand for negotiated market openings a by-product of what has been dubbed the "servicification" of production?[1] What is the role of geography in trade-facilitating regulatory convergence in services? Finally, can the presence of significant developmental or institutional capacity gaps impede integration and convergence in services markets?

This paper seeks answers to the above questions in an Asian setting.[2] According to the WTO's Regional Trade Agreements Information System, 103 PTAs entered into force during January 2008–August 2015. A vast majority of these (exceeding 70% of WTO-notified agreements) included provisions that cover both goods and services trade. Twenty-eight of the 78 STAs notified over the same period involved at least one Asian trading partner, and 11 of these have been entered into with another partner from Asia. Clearly then, Asian economies have been at the forefront of the burgeoning trend toward services preferentialism, offering a potentially fertile setting for exploring this paper's core research questions.

Regulatory heterogeneity has been shown to exert a significantly negative impact on bilateral services trade via Mode 3 (commercial presence) (Kox and Nordås 2009) and commercial presence is the most dominant mode of service delivery, accounting for 55%–60% of all services trade flows (Maurer and Magdeleine 2008). We would thus expect trading partners in a services accord to exhibit lower levels of regulatory heterogeneity compared to those that are not

[1] For a fuller discussion of servicification, see National Board of Trade (2012).

[2] For the purpose of this paper, Asia comprises Bangladesh, Cambodia, the People's Republic of China, India, Indonesia, Japan, the Republic of Korea, Sri Lanka, Malaysia, Mongolia, Nepal, Pakistan, the Philippines, Thailand, and Viet Nam. These are the economies for which information on services regulation is available in the World Bank's Services Trade Restrictiveness Index (STRI) database (Borchert, Gootiiz, and Mattoo 2012).

party to such an agreement. Interestingly, this was not found to be true for the Asian economies studied in this paper. The causal links actually run in the opposite direction.

Regulatory approximation or convergence thus appears as one of the main objectives of negotiated services agreements rather than its chief determinant: the greater the extent of regulatory heterogeneity between trading partners, the more likely are they to enter into a services agreement to promote trade- and investment-facilitating regulatory convergence. Significantly, this proposition is validated by the empirical analysis undertaken for our sample economies, also lending support to the hypothesis that servicification trends—the heightened share of services value added in final production—generate demands to lower the services costs that may arise from regulatory heterogeneity.

II. Related Literature

Services preferentialism has spawned three strands of literature to date. A first strand has investigated the trade effect of services accords on aggregate and disaggregated services trade flows, using advanced estimation techniques from the rapidly evolving gravity model empirical literature (Park 2002; Francois and Hoekman 2010; Grünfeld and Moxnes 2003; Kimura and Lee 2004; Lennon 2009; Marchetti 2011; Shingal 2014a, 2014b; van der Marel and Shepherd 2013; Walsh 2006).[3]

A second strand has explored the impact that differing levels of (and heterogeneity in) regulation exert on bilateral services trade flows (Francois, Hoekman, and Woerz 2007; Fink 2009; Kox and Lejour 2006; Kox and Nordås 2007, 2009; Schwellnus 2007; van der Marel and Shepherd 2013). A third strand has resorted to theoretical and empirical techniques to estimate barriers to trade in services and foreign direct investment, and/or to provide estimates of services trade costs (Francois, Hoekman, and Woerz 2007; Miroudot, Sauvage, and Shepherd 2012, 2013; van der Marel 2011).

The literature has also evolved to explain services commitments in the General Agreement on Trade in Services (GATS) (Roy 2011), those made reciprocally (Marchetti, Roy, and Zoratto 2012), as well as GATS+ commitments in STAs (van der Marel and Miroudot 2014).

The papers closest to ours include Baier and Bergstrand (2004), who were the first to examine the determinants of partners' propensities to negotiate PTAs, and Cole and Guillin (2015) and Egger and Wamser (2013), who explored this issue for services accords. The latter two papers, however, did not consider regulatory convergence as a determinant for entering into negotiations. Studying the role of

[3] An elaboration of these techniques is beyond the scope of this paper but an excellent review is provided in Head and Mayer (2014).

regulatory convergence is thus the main contribution of this paper. This is done through recourse to a new World Bank dataset on measures of services (regulatory) restrictiveness (Borchert, Gootiiz, and Mattoo 2012).[4]

Baier and Bergstrand (2004) found the potential welfare gains and likelihood of a PTA in goods trade between a pair of economies to be higher

(i) the closer the two trading partners are in terms of geographic distance;

(ii) the more remote they are from the rest of the world (ROW);

(iii) the larger and more similar they are economically, in terms of real gross domestic product (GDP), to enable exploitation of economies of scale in the presence of differentiated products;

(iv) the greater the difference in relative factor endowments between them, leading to Heckscher–Ohlin trade; and

(v) the smaller the difference in the relative factor endowment ratios relative to those of the ROW, leading to less interindustry trade diversion.

Baier and Bergstrand (2004) found these factors to have economically and statistically significant effects on the probability of negotiating a goods agreement.

In comparison, Cole and Guillin (2015) examined a dyad's propensity to negotiate a services agreement, and in their baseline specification found statistically significant evidence only for the natural trading partner hypothesis, similarity in terms of economic size, and relative factor endowment differences—both those emanating from Heckscher–Ohlin trade and those leading to less interindustry trade diversion. Egger and Wamser (2013) found the determinants of goods and services trade agreements to be similar.

III. Regulation in Services Trade

Regulatory measures affect cross-border trade and investment in services by increasing both the fixed cost of entering a market and the variable cost of servicing that market. Where regulation is destination specific, such costs can become sunk, which makes the decision to export similar to an investment decision and involves a self-selection process studied in the heterogeneous firm trade literature (Melitz 2003; Helpman, Melitz, and Yeaple 2004; Bernard et al. 2007; Chaney 2008). Essentially, only firms with the highest productivity and/or lowest marginal costs tend

[4]See the World Bank's STRI database at http://iresearch.worldbank.org/servicetrade/home.htm

Table 1. **Comparison of STRI across Regions and Groups**

Region or Group	LAC	ECA	EAP	OECD	SSA	SA	MENA	World
Mean	21.6	18.8	39.1	19.1	32.0	43.9	45.2	28.3
Standard deviation	10.0	6.7	13.9	4.8	16.6	13.7	11.2	14.9

EAP = East Asia and the Pacific, ECA = Eastern Europe and Central Asia, LAC = Latin America and the Caribbean, MENA = Middle East and North Africa, OECD = Organisation for Economic Co-operation and Development, SA = South Asia, SSA = Sub-Saharan Africa, STRI = Services Trade Restrictiveness Index.
Source: Authors' calculations based on World Bank STRI database.

to profitably overcome sunk market-entry costs, thereby self-selecting themselves into becoming exporters.

In the context of an STA between trading partners, regulatory requirements assume significance for firms in both markets and the objective of the agreement is usually twofold: (i) to reduce the level and incidence of restrictive regulation in both markets; and (ii) to promote convergence and approximation, including through mutual recognition, and ultimately (but less frequently and successfully) to harmonize regulatory practices between trading partners.

The measure of regulation in services markets used in this paper is the Services Trade Restrictiveness Index (STRI) recently released by the World Bank. Compiled from responses to questionnaires sent by the World Bank to 79 developing economies on impediments to international integration, and from publicly available information for Organisation for Economic Co-operation and Development (OECD) economies, STRI is a quantitative index of restrictions on services trade encompassing 103 economies, 5 major service sectors, and 19 subsectors. The information is also available by mode of service delivery.

A comparison of STRI by regions and groups in Table 1 shows that the Middle East and North Africa has the most restrictive services trade policies, followed by South Asia, East Asia and the Pacific, and Sub-Saharan Africa, with the last also being the most heterogeneous cohort. As expected, OECD economies and Eastern Europe and Central Asia not only report the lowest STRI values but also form the most homogeneous cohorts. Significantly, the Asian regions are not only very restrictive but also highly heterogeneous in terms of services trade impediments, which again make Asia a relevant case study for the purposes of this enquiry.

A closer look at Table 1 provides an intuitive feel for the factors likely to make economies potential candidates for negotiated regulatory convergence. For instance, high levels of per capita income, economic development, and political stability all likely contribute to the observed homogeneity in STRI among OECD economies despite significant differences in language, culture, and distances within this cohort. In the case of Eastern Europe and Central Asia, on the other hand, there is greater homogeneity of language, culture, and distances, though more differences in terms of per capita income and economic development. This suggests that a combination

of these factors could determine which economies are potential candidates for negotiated regulatory convergence.

IV. Empirical Methodology

Our empirical framework draws on McFadden's (1975, 1976) qualitative choice models where utility, here the (minimum or average) net gains for two economies from participating in an STA, is modeled as a latent, unobservable variable (y^*), which can be explained by a vector of explanatory variables (x). Since $y*$ cannot be observed, an indicator variable STA is used that takes the value 1 (indicating $y^* > 0$) if two economies participate in a common STA and 0 (indicating $y^* \leq 0$) otherwise.

More formally,

$$STA = 1 \text{ if } y^* > 0 \text{ and } P(STA = 1) = P(y^* > 0) = G(\alpha + \beta x_{ij}) \quad (1)$$

where P is the response probability associated with a trading dyad (ij) signing a services accord, $G(.)$ is a cumulative distribution function that ensures that $P(STA_{ij} = 1)$ lies in the unit interval, and x_{ij} is the vector of explanatory variables for a generic economy pair.

Consistent with Baier and Bergstrand (2004), empirically (1) is estimated by a probit model, assuming normality about the error term in the latent process. Clearly, independent of the assumed cumulative distribution function, the nonlinear nature of $G(.)$ implies that the coefficient estimates only reveal the signs of the partial effects of changes in x_{ij} on the probability of signing an STA. Thus, the direction of the effect of variable x_k on $E(y^* \mid x) = \alpha + \beta x$ is only qualitatively (not quantitatively) identical to the effect of x_k on $E(STA \mid x) = G(\alpha + \beta x)$, where $E(.)$ denotes the expectation operator.

As a robustness check, however, we also estimate (1) using the linear probability model (LPM).

V. Explanatory Variables

In their seminal work exploring the determinants of partners' propensities to negotiate bilateral trade agreements, Baier and Bergstrand (2004) documented that distance, remoteness, size of the economy, and relative factor endowments were the main economic determinants of goods trade agreement membership and that their impact on empirical membership probability was consistent with economic theory. Following them, we use a largely overlapping set of determinants in our empirical analyses.

For any dyad ij, we include $DIST_{ij}$, which is the log of bilateral distance between i and j. Economy sizes are represented by $SRGDP_{ij}$, which is the sum of the

logs of real GDP of economies *i* and *j*, and $DRGDP_{ij}$, which is the absolute value of the difference between the logs of real GDP of both economies.

DKL_{ij} and $DROWKL_{ij}$ determine the role of factor endowments in economies' propensities to negotiate agreements. DKL_{ij} is the absolute value of the difference between the logs of capital–labor ratios of economies *i* and *j*. Apart from DKL_{ij}, Baier and Bergstrand (2004) suggest using $SQDKL_{ij}$—the squared value of DKL_{ij}—in order to control for the likely nonlinear impact of DKL_{ij} on the net gains from participating in a trade agreement. Moreover, to account for dependence of *i* and *j* on each other, Baier and Bergstrand (2004) suggested including $DROWKL_{ij}$, which is calculated as the absolute value of the difference between the logs of capital–labor ratios of economies *i* and *j* and those of the ROW.

Formally,

$$DROWKL_{ij} = \frac{1}{2}\left[\left|log\left[\frac{\sum_{k=1,k\neq i}^{N} K_k}{\sum_{k=1,k\neq i}^{N} L_k}\right] - log\left(\frac{K_i}{L_i}\right)\right| + \left|log\left[\frac{\sum_{k=1,k\neq j}^{N} K_k}{\sum_{k=1,k\neq j}^{N} L_k}\right] - log\left(\frac{K_j}{L_j}\right)\right|\right]$$

Cultural determinants include having a common language ($COMLANG_{ij}$), being a part of the same former colony ($COLONY_{ij}$), having a common colonizer ($COMCOL_{ij}$), having common legal origins ($COMLAW_{ij}$), and being a part of the same country in the past ($SAMECTRY_{ij}$). More importantly from the perspective of this paper, we also control for the level of services regulation in the dyad ($SREG_{ij}$, which is the sum of the logs of STRI of economies *i* and *j*) and regulatory heterogeneity between partners by including the absolute value of the difference between the logs of STRI of both economies ($DREG_{ij}$).

Finally, to examine the role of embedded supply chains in the region and complementarities between goods and services trade, we include the log of average merchandise trade between economies *i* and *j* (BTG_{ij}) as an additional explanatory variable.

The testable propositions from Baier and Bergstrand (2004) are likely to be similar for STA membership as well. Thus,

(i) economies are more likely to negotiate accords with geographically closer economies, though the effect of distance is likely to be benign for services traded over the internet;

(ii) similar and larger economies are also likely to gain more due to the exploitation of economies of scale and the presence of greater varieties flowing from deeper integration in services markets;

(iii) the greater the difference in relative factor endowments between economies, and the larger the intercontinental trade costs, the more trade creation there is likely to be;

(iv) the greater the difference in relative factor endowments between potential partners and the ROW, the more likely trade diversion becomes;

(v) dyads with common cultural factors and homogeneity in regulation are more likely to enter into agreements as are partners with low initial barriers to services trade; and

(vi) partners with high levels of existing bilateral trade in goods are also more likely to negotiate STAs, not least because the intensity of such trade (and the competitiveness of goods exporters) stands to be enhanced through a negotiated lowering of services input costs.

In estimating Equation (1), we thus expect the coefficients of $SRGDP_{ij}$, DKL_{ij}, $SQDKL_{ij}$, BTG_{ij}, and the cultural variables to be positive, while those of $DIST_{ij}$, $DRGDP_{ij}$, $DROWKL_{ij}$, $SREG_{ij}$, and $DREG_{ij}$ are expected to be negative.

VI. Data

Data on trade agreements are taken from the WTO's Regional Trade Agreements Information System database, where STA = 1 for agreements notified under Article V of the GATS through August 2015 and 0 otherwise. With the exception of the PRC, the STRI for all economies in our sample relates to 2008. Since regulatory convergence is an objective of services preferentialism, to minimize endogeneity in our estimation emanating from reverse causality we only consider services accords that came into effect in 2008 or later.[5] The STRI for the PRC pertains to 2011. However, the PRC has only concluded one services accord to date (with Pakistan) among our sample of Asian economies since January 2008, which is unlikely to influence either its STRI considerably or this paper's overall results.

The earliest STA involving at least one Asian partner (New Zealand–Singapore) entered into effect on 1 January 2001. Since trade agreements are typically phased in over multiyear transition periods and to control for potential endogeneity in our estimation, our data on the time-varying independent variables

[5]Only two services agreements were negotiated between Asian economies prior to 2008: Japan–Malaysia (2006) and Japan–Thailand (2007). Our sample size thus remains effectively the same even without these two agreements.

are averages for 1979–1981 and centered on 1980. The choice of this early year is also likely to control for any domino effects that the earliest STAs may have exerted on the recent wave of services preferentialism involving Asian economies. As robustness checks, however, we also include data on the time-varying independent variables averaged for 1989–1991 and 1999–2001 in separate regressions.[6] The Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) gravity dataset (Head, Mayer, and Ries 2010) provides geographic distances between capital cities that are used to compute $DIST_{ij}$. Data on real GDP are taken from the World Bank's *World Development Indicators* and these are used to calculate $SRGDP_{ij}$ and $DRGDP_{ij}$. We approximate the relative factor endowment ratios (K_i/L_i) by using data on real per capita income for two reasons: (i) using the perpetual inventory method to estimate capital stocks as in Baier and Bergstrand (2004) in earlier time periods leads to an unjustifiable loss of observations, and (ii) real per capita incomes are highly correlated with capital–labor ratios (Egger and Larch 2008; Bergstrand, Egger, and Larch 2016). Data on real per capita income are also taken from the World Bank's *World Development Indicators*.

Data on common language and colonial antecedents are taken from the CEPII gravity dataset (Head, Mayer, and Ries 2010), while data on legal origins were compiled using La Porta et al. (1999). The World Bank's STRI data (Borchert, Gootiiz, and Mattoo 2012) are used to calculate $SREG_{ij}$ and $DREG_{ij}$. Data used to calculate BTG_{ij} were sourced from the United Nations Commodity Trade Statistics Database (UN Comtrade). To the extent possible, all trade data were also averaged for 1979–1981, 1989–1991, and 1999–2001 to minimize fluctuations in recording practices.[7] Descriptive statistics are provided in Table 2.

VII. Results

The results from the LPM and probit estimation of Equation (1), assuming exogenous unilateral STRI, are reported in Table 3. In the first two columns of Table 3, the time-varying regressors are averaged for 1979–1981. In columns (3) and (4), the time-varying regressors are averaged for 1989–1991, while in columns (5) and (6), these are averaged for 1999–2001. Standard errors are clustered by trading partner pair in all specifications.

Unfortunately, with data on time-varying regressors averaged for 1979–1981, the small number of observations meant that the probit model was left with no degrees of freedom to contend with. We thus focus on the LPM results reported in

[6] We would like to thank an anonymous referee for this suggestion.

[7] In some cases, the earliest available years were 1984–1986 (the PRC), 1998–2000 (Mongolia and Viet Nam), and 2000–2002 (Cambodia).

Table 2. **Descriptive Statistics**

Variable	Acronym	Obs.	Mean	Std. Dev.	Min.	Max.
Services Trade Agreement Membership						
STA membership status between *i* and *j* in 2015 (end-August)	STA_{ij}	103	0.136	0.344	0.000	1.000
Unilateral Services Trade Restrictiveness						
Log sum of STRI of *i* and *j*	$SREG_{ij}$	103	7.165	0.554	5.757	8.165
Absolute difference in log STRI of *i* and *j*	$DREG_{ij}$	103	0.464	0.358	0.013	1.568
Absolute and Relative Endowment and Trade Variables (avg 1979–1981)						
Log sum of GDP of *i* and *j*	$SRGDP_{ij}$	76	48.880	2.551	42.643	54.625
Absolute difference in log GDP of *i* and *j*	$DRGDP_{ij}$	76	2.218	1.649	0.016	7.626
Absolute difference in log GDP per capita of *i* and *j*	DKL_{ij}	76	1.431	1.184	0.004	4.734
Squared absolute difference in log GDP per capita of *i* and *j*	$SQDKL_{ij}$	76	3.431	5.228	0.000	22.411
Absolute difference in log GDP per capita of *i* plus *j* with the rest of the world	$DROWKL_{ij}$	76	2.135	0.618	0.513	3.355
Log average bilateral goods trade between *i* and *j*	BTG_{ij}	68	16.477	2.793	8.375	22.587
Absolute and Relative Endowment and Trade Variables (avg 1989–1991)						
Log sum of GDP of *i* and *j*	$SRGDP_{ij}$	89	49.799	2.607	43.491	55.983
Absolute difference in log GDP of *i* and *j*	$DRGDP_{ij}$	89	2.298	1.636	0.016	7.654
Absolute difference in log GDP per capita of *i* and *j*	DKL_{ij}	89	1.473	1.271	0.005	4.917
Squared absolute difference in log GDP per capita of *i* and *j*	$SQDKL_{ij}$	89	3.766	5.696	0.000	24.174
Absolute difference in log GDP per capita of *i* plus *j* with the rest of the world	$DROWKL_{ij}$	89	2.093	0.563	0.519	3.110
Log average bilateral goods trade between *i* and *j*	BTG_{ij}	83	17.656	2.630	9.628	23.442
Absolute and Relative Endowment and Trade Variables (avg 1999–2001)						
Log sum of GDP of *i* and *j*	$SRGDP_{ij}$	103	50.312	2.839	43.457	57.072
Absolute difference in log GDP of *i* and *j*	$DRGDP_{ij}$	103	2.524	1.740	0.039	7.744
Absolute difference in log GDP per capita of *i* and *j*	DKL_{ij}	103	1.459	1.274	0.016	4.761
Squared absolute difference in log GDP per capita of *i* and *j*	$SQDKL_{ij}$	103	3.738	5.489	0.000	22.664
Absolute difference in log GDP per capita of *i* plus *j* with the rest of the world	$DROWKL_{ij}$	103	2.026	0.518	0.581	3.068
Log average bilateral goods trade between *i* and *j*	BTG_{ij}	103	17.920	3.375	8.922	24.404
Geographical and Cultural Distance						
Log bilateral distance between *i* and *j*	$DIST_{ij}$	103	7.952	0.543	6.284	8.834
Common legal system between *i* and *j*	$COMLAW_{ij}$	103	0.291	0.457	0.000	1.000
Common language between *i* and *j*	$COMLANG_{ij}$	103	0.087	0.284	0.000	1.000
Colonial relationship between *i* and *j*	$COLONY_{ij}$	103	0.019	0.139	0.000	1.000
Common colonizer between *i* and *j*	$COMCOL_{ij}$	103	0.107	0.310	0.000	1.000
Units *i* and *j* belonged to the same country	$SAMECTRY_{ij}$	103	0.049	0.216	0.000	1.000

GDP = gross domestic product, STA = services trade agreement, STRI = Services Trade Restrictiveness Index.
Sources: World Trade Organization. Regional Trade Agreements Information System. http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx; Borchert, Gootiiz, and Mattoo 2012; World Bank. World Development Indicators. http://data.worldbank.org/data-catalog/world-development-indicators; United Nations. UN Commodity Trade Statistics Database. http://comtrade.un.org/; Head, Mayer, and Ries 2010; La Porta et al. 1999.

Table 3. **Explaining STA Membership within Asia, Assuming Exogenous Unilateral STRI**

	Dependent Variable: STA Membership					
Time-Varying Regressors Averaged Over	**(1) LPM**	**(2) Probit**	**(3) LPM**	**(4) Probit**	**(5) LPM**	**(6) Probit**
	1979–1981		**1989–1991**		**1999–2001**	
$DIST_{ij}$	−0.020	11.016	0.028	1.143	0.096	2.016**
	(0.106)	.	(0.080)	(0.863)	(0.068)	(0.774)
$SRGDP_{ij}$	−0.029	7.157	−0.013	−0.872	−0.005	−0.687#
	(0.036)	.	(0.031)	(0.715)	(0.033)	(0.358)
$DRGDP_{ij}$	−0.053	−1.768	−0.039	−0.012	−0.047*	−0.059
	(0.039)	(0.000)	(0.029)	(0.213)	(0.019)	(0.158)
DKL_{ij}	0.216	−5.482	0.103	−0.909	0.138#	0.864
	(0.145)	(0.000)	(0.124)	(1.593)	(0.073)	(0.943)
$SQDKL_{ij}$	−0.038	0.338	−0.014	0.190	−0.014	−0.119
	(0.030)	.	(0.029)	(0.278)	(0.021)	(0.252)
$DROWKL_{ij}$	−0.057	−16.825	−0.012	−0.138	0.060	0.802
	(0.101)	(0.000)	(0.090)	(1.415)	(0.077)	(0.650)
BTG_{ij}	0.088**	−1.260	0.057#	1.563*	0.050*	1.153***
	(0.026)	(0.000)	(0.031)	(0.618)	(0.023)	(0.303)
$SREG_{ij}$	0.098	−0.382	−0.004	0.139	−0.064	−1.023
	(0.101)	(0.000)	(0.132)	(1.023)	(0.092)	(0.658)
$DREG_{ij}$	0.818***	13.760	0.599***	5.374***	0.334**	2.083*
	(0.120)	.	(0.164)	(1.470)	(0.112)	(0.909)
$COMLAW_{ij}$	0.027	7.907	0.008	−4.494***	0.005	−4.019***
	(0.121)	.	(0.076)	(0.787)	(0.046)	(1.193)
$COMLANG_{ij}$	−0.044	−2.255	−0.042	0.062	0.004	0.026
	(0.112)	(0.000)	(0.106)	(0.610)	(0.114)	(0.639)
$COLONY_{ij}$	−0.211	.	−0.254	.	−0.104	.
	(0.263)	.	(0.224)	.	(0.174)	.
$COMCOL_{ij}$	0.062	15.294	0.116	5.190***	0.169	5.394***
	(0.143)	.	(0.147)	(1.278)	(0.129)	(1.184)
$SAMECTRY_{ij}$	−0.238	.	−0.349*	.	−0.288#	.
	(0.189)	.	(0.171)	.	(0.154)	.
Constant	−0.764	−397.235	−0.601	2.037	−1.097	−0.750
	(1.795)	(0.000)	(1.461)	(20.402)	(1.091)	(11.329)
N	55	51	78	72	103	96
df_m	13	0	14	12	14	12
r^2	0.683		0.457		0.403	
Explanatory power	0.8264	0.6757	0.6757	0.553	0.6346	0.5081
Number of predictions at which $P(STA_{ij} = 1) < 0$	16		22		32	
Correct predictions (%)						
overall				94.2		95.1
for STA = 1				64.3		85.7
for STA = 0				98.9		96.6

LPM = linear probability model, STA = services trade agreement, STRI = Services Trade Restrictiveness Index.
Notes: # = 10% level of significance, * = 5% level of significance, ** = 1% level of significance, *** = 0.1% level of significance. Standard errors, clustered by trading partner pair, are reported in parentheses.
Source: Authors' calculations.

column (1), which suggest that only BTG_{ij} and $DREG_{ij}$ were statistically significant determinants of STA membership in Asia for the earliest time period (1979–1981). Moreover, while the coefficient of BTG_{ij} is positive as predicted, that of $DREG_{ij}$ is also positive, which runs counter to our predictions. The latter suggests that Asian trading partners with divergent regulatory frameworks may in fact be negotiating services accords to foster regulatory convergence. The explanatory power of the LPM was also found to be high at 0.8264.

The results from the LPM with data on time-varying explanatory variables averaged for 1989–1991 and reported in column (3) were qualitatively similar to those reported in column (1), though the positive coefficient of BTG_{ij} was now found to be weakly significant. Moreover, being a part of the same economy in the past seemed to have a negative impact on the propensity to negotiate services accords in Asia.

The probit results reported in column (4) provided evidence for the positive role of BTG_{ij}, $DREG_{ij}$, and having a common colonizer ($COMCOL_{ij}$), but provided evidence for the negative role of a common legal system ($COMLAW_{ij}$) in determining STA membership in Asia. Significantly, the probit model correctly predicted STA membership for 94.2% of the observations in our sample.[8] Of the total, 14 dyads actually negotiated an STA and nine of these were correctly predicted by our model. The remaining 89 dyads did not have a services accord and our model correctly predicted 88 (98.9%) of these.

With data on time-varying regressors averaged for 1999–2001, more explanatory variables exhibit statistical significance in the LPM and probit results reported in columns (5) and (6), respectively, but some of these results are also more counterintuitive. For instance, the coefficient of $DIST_{ij}$ is positive (thus negating the role of geography in the choice of STA partners within Asia) and that of $SRGDP_{ij}$ is negative (thus negating the role of the size of potential markets) in the probit results in column (6), both of which run counter to theoretical predictions in Baier and Bergstrand (2004). Given that the underlying data on time-varying regressors has been averaged for 1999–2001 in these results, potential endogeneity in the estimation cannot be ruled out.

We thus focus on the results reported in columns (1) through (4) to explain STA membership in Asia and these results suggest that trading partner pairs with greater historical levels of bilateral merchandise trade and wider differences in their services regulatory frameworks are more likely candidates for STA formation in Asia. Thus, the servicification hypothesis appears to command the strongest empirical appeal in explaining our sample economies' propensities to sign services accords.

[8]To enable this comparison, we used the decision-rule from Baier and Bergstrand (2004). If $STA_{ij}^{pred} > 0.5$, then we take this value to be 1. If $STA_{ij}^{pred} <= 0$, then we take this value to be 0.

A. Endogenous Unilateral STRI

In this subsection, we relax the assumption of the exogeneity of the services regulatory frameworks.

The main objective of STAs is to increase trade in services between partners. Reducing levels of restrictive regulation and promoting regulatory convergence are important channels through which services accords expand services trade volumes. Thus, the determinants of an economy's choice to negotiate a services accord are likely to be indistinguishable from those that inform whether certain economies are more likely candidates for a reduction in restrictive regulation levels as well as for regulatory convergence.

To examine this secondary hypothesis, in distinct regressions, we explain the restrictiveness of services regimes in a dyad and regulatory heterogeneity between partners using the same set of controls as used for explaining STA membership in Equation (1).

Formally,

$$DREG_{ij} = \theta + \pi x_{ij} + \varepsilon_{ij} \tag{2}$$

where $DREG_{ij}$ is the absolute value of the difference between the logs of the STRI of two economies and ε_{ij} is the error term.

Moreover,

$$SREG_{ij} = \mu + \eta x_{ij} + \xi_{ij} \tag{3}$$

where $SREG_{ij}$ is the sum of the log levels of STRI of two economies and ξ_{ij} is the error term.

We then use the predicted values of $DREG_{ij}$ and $SREG_{ij}$ from Equations (2) and (3), respectively, as additional control variables in Equation (1). The statistically significant coefficients of $DREG_{ij}^{pred}$ and $SREG_{ij}^{pred}$ suggest that these variables were endogenous in explaining STA membership, thereby validating our secondary hypothesis. Equations (2) and (3) were estimated using ordinary least squares but these results are not reported.

The results from the LPM and probit estimation of Equation (1), testing for the endogenous treatment of STRI, are reported in Table 4. Once again, the time-varying regressors are averaged for 1979–1981 in the first two columns of Table 4. In columns (3) and (4), the time-varying regressors are averaged for 1989–1991, while in columns (5) and (6), these are averaged for 1999–2001. Standard errors are clustered by trading partner pair in all specifications.

While the overall results from these regressions are qualitatively similar to those reported in Table 3, the coefficient of $DREG_{ij}^{pred}$ is omitted and that of

Table 4. **Explaining STA Membership within Asia, Allowing for Endogenous Unilateral STRI**

	Dependent Variable: STA Membership					
Time-Varying Regressors Averaged Over	**(1) LPM 1979–1981**	**(2) Probit 1979–1981**	**(3) LPM 1989–1991**	**(4) Probit 1989–1991**	**(5) LPM 1999–2001**	**(6) Probit 1999–2001**
$DIST_{ij}$	0.007	11.016	0.051	1.143	0.106#	2.016**
	(0.102)	.	(0.078)	(0.863)	(0.061)	(0.774)
$SRGDP_{ij}$	−0.041	7.157	−0.021	−0.872	−0.008	−0.687#
	(0.028)	.	(0.030)	(0.715)	(0.030)	(0.358)
$DRGDP_{ij}$	−0.034	−1.768	−0.022	−0.012	−0.041#	−0.059
	(0.050)	(0.000)	(0.032)	(0.213)	(0.021)	(0.158)
DKL_{ij}	0.219	−5.482	0.106	−0.909	0.144#	0.864
	(0.145)	(0.000)	(0.123)	(1.593)	(0.074)	(0.943)
$SQDKL_{ij}$	−0.035	0.338	−0.010	0.190	−0.013	−0.119
	(0.030)	.	(0.029)	(0.278)	(0.020)	(0.252)
$DROWKL_{ij}$	−0.106	−16.825	−0.051	−0.138	0.039	0.802
	(0.138)	(0.000)	(0.093)	(1.415)	(0.080)	(0.650)
BTG_{ij}	0.089**	−1.260	0.058#	1.563*	0.044#	1.153***
	(0.026)	(0.000)	(0.031)	(0.618)	(0.026)	(0.303)
$SREG_{ij}$	0.262	−0.382	0.199#	0.139	0.010	−1.023
	(0.191)	(0.000)	(0.111)	(1.023)	(0.076)	(0.658)
$DREG_{ij}$	0.818***	13.760	0.599***	5.374***	0.334**	2.083*
	(0.120)	.	(0.164)	(1.470)	(0.112)	(0.909)
$COMLAW_{ij}$	0.009	7.907	−0.025	−4.494***	−0.006	−4.019***
	(0.115)	.	(0.075)	(0.787)	(0.049)	(1.193)
$COMLANG_{ij}$	−0.044	−2.255	−0.065	0.062	−0.008	0.026
	(0.112)	(0.000)	(0.108)	(0.610)	(0.118)	(0.639)
$COLONY_{ij}$	.	.	.	.	.	.
$COMCOL_{ij}$	0.063	15.294	0.110	5.190***	0.156	5.394***
	(0.143)	.	(0.148)	(1.278)	(0.129)	(1.184)
$SAMECTRY_{ij}$	−0.159	.	−0.246	.	−0.231	.
	(0.203)	.	(0.155)	.	(0.141)	.
$DREG_{ij}^{pred}$	.	.	.	.	.	.
$SREG_{ij}^{pred}$	−0.165	.	−0.203	.	−0.074	.
	(0.205)	.	(0.179)	.	(0.124)	.
Constant	−1.539	−397.235	−1.852	2.037	−1.450	−0.750
	(2.240)	(0.000)	(1.526)	(20.402)	(1.287)	(11.329)
N	55	51	78	72	103	96
df_m	13	0	14	12	14	12
r^2	0.683		0.457		0.403	
Explanatory power	0.8264	0.6757	0.6757	0.553	0.6346	0.5081
Number of predictions at which $P(STA_{ij} = 1) < 0$	17		22		32	
Test for $SREG^{pred} = 0$ (p-value)	0.4247		0.2606		0.5514	

LPM = linear probability model, STA = services trade agreement, STRI = Services Trade Restrictiveness Index.
Notes: # = 10% level of significance, * = 5% level of significance, ** = 1% level of significance, *** = 0.1% level of significance. Standard errors, clustered by trading partner pair, are reported in parentheses.
Source: Authors' calculations.

$SREG_{ij}^{pred}$ is statistically indifferent from 0, thereby pointing to the validity of the exogenous treatment of the services regulatory frameworks in our baseline estimations of Equation (1). This is also confirmed by the p-values of the parameter tests reported at the bottom of Table 4.

VIII. Concluding Remarks

This paper explores the question of whether certain economies within Asia are more likely candidates for negotiated regulatory convergence and harmonization in the context of services agreements. The two papers closest to the analysis on offer in this paper are Baier and Bergstrand (2004), who were the first to ask this question from the perspective of agreements focusing on goods trade, and Cole and Guillin (2015), who first explored the issue for services accords without, however, considering the influence of regulation in services trade.

While our results may be Asia-specific, the goodness-of-fit of our empirical model, demonstrated by the probabilities that were predicted successfully, is in line with the results found in Baier and Bergstrand (2004) and improves on those found in Cole and Guillin (2015). Our results suggest that Asian economies with high preexisting levels of bilateral goods trade and divergent services regulatory frameworks are more likely to negotiate services agreements with each other.

A number of policy implications can be derived from the above results. For starters, far from inhibiting the quest for deeper market integration, ex ante divergences in regulatory regimes and enforcement capacities may well prove a significant spur to negotiated convergence, allowing parties to import best trade- and investment-facilitating standards from partners with greater overall regulatory efficiency. Where regulatory divergences are so marked as to inhibit market integration, the supply of adequate doses of variable geometry in meeting otherwise common policy objectives may represent a useful means to promote convergence. A case in point is the Association of Southeast Asian Nations where, despite far-reaching income and development gaps within the regional grouping, significant regulatory convergence has been achieved through formulas that internalize the need for differentiated implementation modalities across members.

Among economic variables, the positive and significant relationship found between past bilateral trade flows and STA membership in Asia clearly stands out. This may lend support to the idea that binding agreements in the area of services are increasingly perceived by governments as important instruments to complement goods trade. This has particular resonance in Asia given the growing role of the region in supply chain production. Producer services (e.g., transportation and logistics, telecommunications, finance, business and professional services) play a significant role in goods-dominated supply chains, and legally binding commitments in treaty instruments (governing both trade and investment) assume heightened value

as they provide a degree of predictability and stability that is essential for the proper functioning of complex cross-border operations (Baldwin and Kawai 2013, Baldwin and Lopez-Gonzalez 2013).

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Examining Monetary Policy Transmission in the People's Republic of China–Structural Change Models with a Monetary Policy Index[+]

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This paper estimates augmented versions of the Investment–Saving curve for the People's Republic of China in an attempt to examine the relationship between monetary policy and the real economy. It endeavors to account for any structural break, nonlinearity, or asymmetry in the transmission process by estimating a breakpoint model and a Markov switching model. The Investment–Saving curve equations are estimated using a Monetary Policy Index, which has been calculated using the Kalman filter. This index will account for the various monetary policy tools, both quantitative and qualitative, that the People's Bank of China has used over the period 1991–2014. The results of this paper suggest that monetary policy has an asymmetric affect depending on the level of output in relation to potential, and that the People's Republic of China's exchange rate policy has restricted the effectiveness of the People's Bank of China's monetary policy response.

Keywords: IS curve, Kalman filter, monetary policy, People's Bank of China, structural change
JEL codes: E12, E42, E58

I. Introduction

The dynamics of monetary policy transmission is arguably the most comprehensive and yet rapidly expanding research area in the discipline of macroeconomics. Taylor (1995) describes the monetary policy transmission channel as the process by which a central bank's monetary policy instruments exert influence on macroeconomic variables such as prices, output, and employment. In most advanced economies, the operating target for the conduct of monetary policy is the interest rate. For example, the United States (US) Federal Reserve has the Fed Funds rate, the European Central Bank has the main refinancing rate, and the Bank

[+] ADB recognizes "China" as the People's Republic of China.

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of England has the base rate. It has been argued, however, that the People's Republic of China's (PRC) central bank, the People's Bank of China (PBOC), uses a variety of policy instruments, both quantitative and qualitative, and so the use of a single interest rate variable may not give an accurate representation of the PBOC's monetary stance (see, for example, Geiger 2008, He and Pauwels 2008, Ma 2014). While some researchers suggest that continued liberalization in the finance sector has improved its effectiveness (Fernald, Hsu, and Spiegel 2014), most studies have found that the interest rate channel in the PRC has been largely ineffective. Since the reforms in 1978, the foundations of the PRC's monetary policy have instead been built on a fixed exchange rate, strict controls on capital flows, and a wide selection of administrative and qualitative policy tools. Over the past 30 years, the PRC's macroeconomic dynamics have been characterized mainly by high gross domestic product (GDP) growth accompanied by erratic business cycle fluctuations. Despite average annual growth of almost 10% per annum over the last 3 decades, the PRC's output volatility has remained consistently high. An IMF (2011) paper states that the PRC's output volatility is twice as high as that of the US. In recovering from the global financial crisis of 2008–2009, the PRC faced serious credit-fueled inflationary concerns. The PRC's monetary authorities addressed this by raising banks' reserve requirement ratios. However, in the pursuit of higher financial openness and exchange rate stability, the PRC is facing the crucial trade-off of having to give up monetary policy independence. This is a perfect example of the trilemma, or impossible trinity problem.[1]

With this is mind, understanding the PBOC's instruments of monetary policy is important in examining how the transition mechanisms affect the real economy. To fully analyze what drives business cycle behavior in the PRC, it is important to carry out a robust study of the relationship between monetary policy, the credit market, and the real economy while allowing for PRC-specific characteristics. It is also crucial to examine if these relationships have changed during the estimation period (1991–2014), given the large number of reforms and institutional changes that typified this period. This paper will attempt to do so by estimating different variations of an Investment–Saving (IS) curve—both a traditional interest rate IS curve and a model estimated using a composite policy index that has been calculated using a Kalman filter in a State Space Model (SSM) form. This index may give a more accurate representation of the instruments at the disposal of the PBOC. This paper will also test, and account for where appropriate, structural breaks, nonlinearity, and asymmetry in the time series to determine if the response or effect of monetary policy has changed or switched in any significant way.

[1] A fundamental contribution of the Mundell-Fleming framework, the impossibly trinity states that an economy may choose two but not all three of the policy goals of monetary policy independence, a fixed exchange rate, and full capital mobility.

The paper presents three main findings. First of all, unlike the majority of the literature in this area, our results find that a standard IS curve equation using a simple PBOC lending rate has a statistically significant impact on the real economy, albeit a small one. Secondly, a composite measure of the monetary policy instruments would seem to give a better explanation of the monetary policy transmission channel once structural breaks, asymmetry, and nonlinearity are accounted for. The breakpoint model finds that the PRC's monetary policy reaction has declined since 1995, and we suggest that this is the result of the adoption of the dollar peg exchange rate regime in 1994. Finally, the results of the Markov switching (MS) model indicate that the PBOC's monetary policy instruments have a stronger effect on the real economy when output is operating at or above potential (positive output gap), but has less of an effect when output is operating below potential (negative output gap). The paper is structured as follows. Section II gives an overview of the literature on monetary policy transmission in the PRC during the reform period (1991–2014). Section III outlines the methodology used in estimating our IS curve. Section IV outlines the data used in our estimations and gives a detailed description of the estimated Monetary Policy Index (MPI). Section V estimates the various IS models and comments on the results of each. Section VI performs robustness tests on our results. Section VII concludes.

II. Literature Review

A number of seminal papers have been written relating the level of aggregate demand to monetary policy. Bernanke and Blinder (1992), Blanchard (1990), and Friedman (1995) are all good examples of the theory that in advanced economies the level of real output is highly responsive to monetary policy. There is, however, a separate branch of research that suggests monetary policy has had little or diminishing impact on the real economy (see, for example, Goodhart and Hofmann 2005). The New Keynesian model of monetary policy has become the standard tool for the analysis of the monetary policy transmission channel. This model consists of a Phillips curve, an IS curve, and a monetary policy rule. According to Goodhart and Hofmann (2005), the IS curve represents the intertemporal Euler consumption equation. It relates the output gap to the expected future output gap and the real interest rate: the higher the interest rate, the lower the output. A great deal of research on this topic in the PRC has focused on understanding the impact of interest rate changes on investment, which accounts for a particularly large share of GDP and growth in the PRC and is an important driver of business cycle volatility (Conway et al. 2010, Liu and Zhang 2010, Kuijs 2006). The PRC's authorities have traditionally relied mainly on administrative instruments and an array of both qualitative and quantitative measures in conducting monetary policy, with interest rates playing a less prominent role (Koivu 2005). So far, the majority of the literature

has supported this argument as macroeconomic evidence of a significant negative relationship between interest rate changes and capital formation in the PRC has been weak. Geiger (2006) argues that changes in interest rates have limited impact on aggregate macro variables and that the transmission of monetary policy via the interest rate channel is distorted. Laurens and Maino (2007) argue that there is no significant link between the PRC's short-term interest rates and movements in GDP. Mehrotra (2007) examines the role of interest rate channels in the PRC; Hong Kong, China; and Japan using a structural vector autoregression model and finds that while there is strong evidence of the interest rate channel as a monetary policy tool for both Japan and Hong Kong, China, the same cannot be said for the PRC. The limited importance of the interest rate channel in the PRC is attributed to the implementation of interest rates by administrative measures rather than market-determined interest rates.

The majority of studies analyzing aggregate demand in the PRC have used standard linear models and found little or no evidence of a relationship between output and monetary policy. Koivu (2009) argues that the reforms and structural breaks during 1998–2007 prevented the estimation of a stable credit demand equation for the PRC. To remedy this, the author estimates the model across two subsample periods, accounting for these structural breaks and reforms. The results seem to support the findings of previous studies that the link from interest rates to the real economy is still quite weak in the PRC. The author did, however, find that the link had strengthened toward the end of the estimation period, suggesting that interest rates have increased in importance along with continued reform in the PRC's finance sector. Qin et al. (2005) find that the overall impact of monetary policy on the real sector of the macroeconomy is small and insubstantial, suggesting that the PRC's monetary policy instruments are not effective tools for controlling output, investment, or employment. In contrast to this, many authors have found that there is a negative link between interest rates and macroeconomic aggregates in the PRC. Girardin and Liu (2007) use a vector autoregression model to investigate the relationship between interest rates and output in the PRC and find that a negative relationship does exist, particularly in the latter half of the sample period 1997–2005. While Conway et al. (2010) argue that an IS equation for the PRC is difficult to estimate, the authors' estimation for 2000–2007 found that both the interest rate and the exchange rate have a statistically significant impact on the real economy in the PRC, even if this impact is relatively small.

There has been very little agreement in the mainstream literature regarding the asymmetric effect of monetary policy; that is, whether monetary policy has a greater effect across different stages of the business cycle. Using US data, Ravn and Sola (2004) and Weise (1999) find that the transmission of monetary policy is very much symmetric. In a more recent paper, Tenreyro and Thwaites (2013) also suggest that monetary policy transmission has asymmetric effects, with the authors finding a greater effect on output (and inflation) in an expansion. Dolado,

Maria-Dolores, and Ruge-Murcia (2005); Peersman and Smets (2001); Aragón and Portugal (2009); and, more recently, Barigozzi et al. (2014) have also investigated the topic of asymmetric monetary policy in eurozone economies. Despite these studies, across advanced economies, no real consensus has been reached in this area of research. As a result, the topic and its policy implications have been largely ignored in the mainstream monetary policy literature.[2] This paper will add to the body of research by testing and accounting for asymmetry in the PRC's economy over the last 25 years. However, the huge difference between the PRC's economy and that of the US and the eurozone requires innovative and perhaps unconventional tools to investigate the monetary policy transmission channel. The presence of structural breaks, changes, nonlinearity, and asymmetry in the transmission channel may be even more prominent in the PRC. There are many reasons to make this inference. This paper examines the monetary policy reactions of the PBOC since late 1991, which is often regarded as the start of the PRC's second reform era. During this period, the PBOC endeavored to pursue a more market-oriented monetary policy framework, which included greater use of indirect instruments. The period also coincided with other institutional reforms and changes that may have greatly affected the monetary policy transmission channel over time.

While there has been a great deal of literature chronicling the PRC's economic policy, in particular the effect of changes in exchange rate policy, less attention has been paid to estimating an indicator for the monetary policy stance and very few studies have accounted for the asymmetric affect that these policies have had on the level of output. Xiong (2012) computes a monetary policy index using an ordered probit model, but stops short of differentiating between asymmetric responses to the PBOC's actions due to changes in the state of the economy, stating that this warrants further investigation.[3] Girardin, Lunven, and Ma (2014) build on the work of He and Pauwels (2008) and Xiong (2012) by constructing an aggregate measure of the PRC's monetary policy stance using price, quantitative, and administrative measures. Finally, Petreski and Jovanovic (2013) create their own MPI using a weighted average of quantitative and qualitative instruments, which is in turn included in the model instead of the interest rate. The estimation of the PRC's monetary policy instruments in this paper is based on this work as it also uses a Kalman filter to extract the qualitative variables. While these papers may have focused on finding an appropriate measurement of monetary policy in the PRC, one oversight in this area of the literature has been the failure to account for structural breaks, asymmetry, and nonlinearity in the transmission process. As has been discussed, this could be particularly relevant to an economy like the PRC's, which has undergone significant change and reform. To our knowledge, this research is the first to apply both a

[2]This argument was made by Tenreyro and Thwaites (2013), who pointed to examples such as Christiano, Eichenbaum, and Evans (2005); and Woodford (2003).

[3]An ordered probit model in this case assigns a number depending on the type of policy that is observed or believed to have been carried out: –1 is contractionary, 0 is neutral, and 1 is expansionary.

linear model with structural breaks and a nonlinear technique (MS model) to the transmission process, as well as a composite index of the monetary policy stance.

III. Methodology

The traditional IS curve takes the form of Equation 1:

$$\bar{y}_t = E_t(\bar{y}_{t+1}) - c[i_t - E_t(\pi_{t+1})] + v_t \quad (1)$$

where $\bar{y}_t$ is the output gap, $(i_t - E_t(\pi_{t+1}))$ is the real interest rate, v_t is a demand-side shock, and c is the response of output to changes in the real interest rate.

Equation 1 is a purely forward-looking equation and relates the output gap to the expected future output gap and the real interest rate. In empirical applications, however, purely forward-looking models have been found to be inconsistent with the dynamics of aggregate demand (Estrella and Fuhrer 2002). Therefore, a backward-looking specification is often preferred in order to match the lagged and persistent responses of output to monetary policy measures that are found in the data (Rudebusch 2002). Backward-looking specifications have been used in many empirical studies, including Fuhrer and Moore (1995), Rudebusch and Svensson (1998), and Goodhart and Hofmann (2005). We can therefore rewrite the equation as

$$\bar{y}_t = a + b\,(\bar{y}_{t-1}) - c\,[(i_{t-1}) - (\pi_{t-1})] + d\,v_t + \varepsilon_t \quad (2)$$

This purely backward-looking specification of the PRC's IS equation can be used in our estimations to obtain dynamics that match those of available economic data most consistently. Macroeconomic data usually shows a high degree of persistence in both inflation and output (Estrella and Fuhrer 2002). According to Ball (1999, 128), the advantage of the backward-looking specification is that it "is similar in spirit to the more complicated macro econometric models of many central banks."

Since the PBOC has adopted a wide range of monetary policy instruments over the last 3 decades, the use of a single variable to adequately capture a monetary policy stance may not be appropriate. A good measure of the monetary policy stance should be able to indicate, either qualitatively or quantitatively, whether policy is becoming contractionary, expansionary, or remaining unchanged (Xiong 2012). Most studies in this area focus on the movement of a single policy variable such as the lending or the deposit interest rate (Xie and Xiong 2003, Conway et al. 2010) or the M2 money supply (Burdekin and Silkos 2008, Koivu 2008). It is commonly accepted that monetary policy in the PRC consists of both quantitative instruments (interest rates, deposit rates, reserve requirement) and qualitative instruments. Qualitative instruments include persuasion and specific directives such as telling banks which

companies to lend to, a practice that is often referred to as window guidance. This policy uses benevolent compulsion to persuade banks and other financial institutions to stick to official guidelines. Central banks put moral pressure on financial players to make them operate consistently with national needs (Geiger 2008). This usually involves influencing market participants through announcements rather than a set of strict rules. Many authors—including Goodfriend and Prasad (2006); Bell and Feng (2013); and Girardin, Lunven, and Ma (2014)—have emphasized the importance of these qualitative instruments with regard to the conduct of the PRC's monetary policy, but the problem from a modeling point of view is that there is no data available for such instruments. How can one model or quantify whether the PBOC informs a particular industry or company to follow their instructions? Therefore, this qualitative instrument variable must be calculated. Once predicted, this series can be used to create an index composed of both the changes in quantitative and qualitative instruments that would more accurately represent the monetary policy stance of the PBOC. The technique of building an index for monetary policy using a variety of techniques has been carried out by Gerlach (2007); Petreski and Jovanovic (2013); and Girardin, Lunven, and Ma (2014).

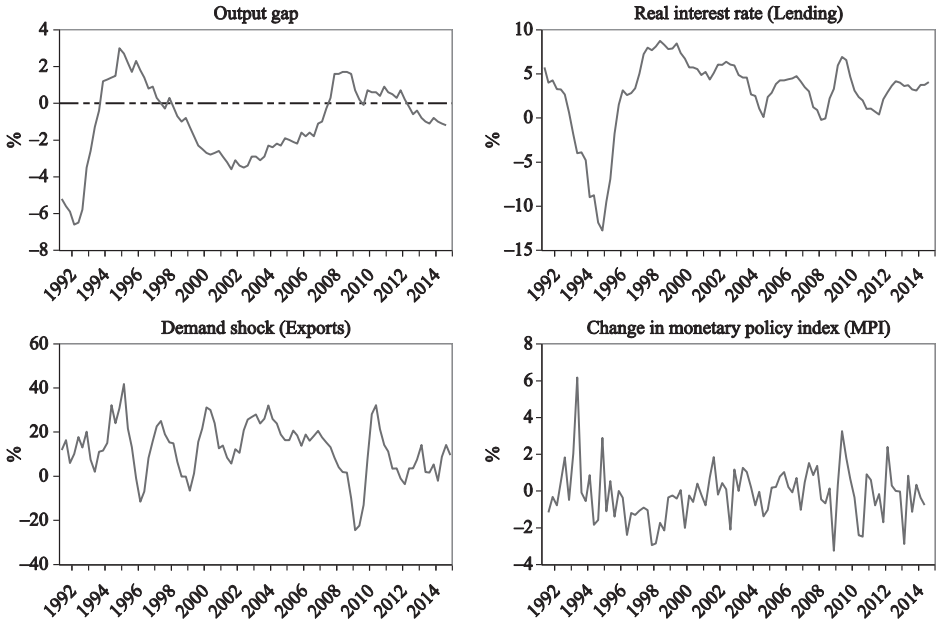
IV. Data

A. Interest Rate and Demand Shock

All variables used in the IS curve estimations are plotted in Figure 1. Seasonal factors have been adjusted for where appropriate. The time period of Q1 1991–Q3 2014 corresponds with the start of the second reform era and was chosen to capture the dynamics of this period of structural changes and institutional reforms. Table 1 reports the unit root tests for all the variables used in our estimations. The results confirm that all variables pass the test for integration of order zero ($I \sim [0]$) and are therefore stationary.

The real interest rate is calculated as $(i_t - \pi_t)$ where i_t is the lending interest rate and π_t is the annual change in quarterly Consumer Price Index. Both of these series are available in the International Monetary Fund's (IMF) *International Financial Statistics* and the PRC's National Bureau of Statistics. For the demand shock, the PRC's seasonally adjusted export data, also found in the IMF's *International Financial Statistics*, is used. The huge importance of the PRC's exports to its growth model over the last 2 decades has been discussed extensively in the literature (Liu, Burridge, and Sinclair 2002; Guo and N'Diaye 2009; Amiti and Freund 2010), and therefore this is the most logical and appropriate demand shock for the PRC's economy. As has been mentioned, the PBOC relies on a basket of different policy tools in the conduct of monetary policy. Therefore, an MPI is required to accurately examine the stance of the PBOC. As no dataset for such an index exists, it will be calculated using the Kalman filter technique. Given the

Figure 1. **IS Curve Estimation Variables, Q1 1991–Q3 2014**



IS = Investment–Saving.
Sources: National Bureau of Statistics. http://www.stats.gov.cn/english/; International Monetary Fund. International Financial Statistics. http://data.imf.org/?sk=5DABAFF2-C5AD-4D27-A175-1253419C02D1; and Oxford Economics. Global Economic Databank. http://www.oxfordeconomics.com/forecasts-and-models/cities/china-cities-and-regional-forecasts/overview (all accessed January 2015); and authors' calculations.

Table 1. **IS Curve Unit Root Test (augmented Dickey-Fuller)**

Variable	**1 lag**	**2 lags**	**3 lags**	**4 lags**	**5 lags**
Output gap, $\bar{y}_t$	−2.60*	−3.23*	−3.50**	−5.76**	−3.05**
	(0.09)	(0.04)	(0.03)	(0.04)	(0.04)
Real interest rate, $i_t - E_t(\pi_{t+1})$	−2.60*	−3.14**	−2.99**	−2.19	−2.73**
	(0.09)	(0.03)	(0.05)	(0.14)	(0.05)
Demand shock (Δ Exports), v_t	−4.54***	−4.82***	−5.69***	−3.92**	−3.19**
	(0.00)	(0.00)	(0.00)	(0.02)	(0.05)
Monetary Policy Index, MPI_t	−5.07***	−4.35***	−4.84***	−3.76***	−2.87*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.09)

IS = Investment–Saving.
Notes: Rejection of the unit root hypothesis at the 10%, 5%, and 1% level is indicated with *, **, and ***, respectively. P-values are in parentheses. Critical values for test with constant are −2.5, −2.8, and −3.4.
Source: Authors' calculations.

importance of this variable for the analysis of the PRC's monetary policy, section IV.C describes the theory, rationale, and calculations behind the MPI. Finally, for the excess demand variable, the output gap is used. As the output gap variable is key to this paper and is the dependent variable for almost all econometric estimations, the next section discusses its calculation and interpretation.

B. The People's Republic of China's Output Gap

The IMF (2015) defines the output gap as the deviation of actual from potential output as a percentage of potential. In the equation below, y denotes actual output (measured by real GDP) and y^* represents potential output, which is defined as the output an economy could produce if all factors of production were operating at their full employment rates of capacity. The output gap can then be represented as $\bar{y} = \frac{y-y^*}{y^*} \times 100$.

Gerlach and Peng (2006) identify two broad approaches to estimating potential output, and thus the output gap, for the PRC:[4]

- a production function approach, which makes use of information regarding the sources of growth (i.e., factor accumulation and the state of total factor productivity); and

- by identifying the trend in real GDP with potential output and using time series techniques, such as filtering, to estimate it.

We will examine these two techniques for our output gap data for the PRC.

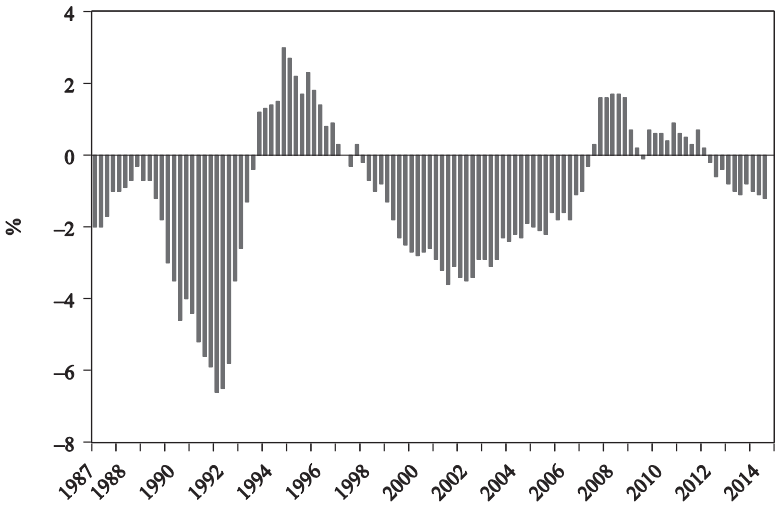
1. Production Function

The main advantage of the production function approach is that it provides an understanding of the sources of growth. However, to estimate a level of potential output in this way requires high-quality data on the capital stock and labor force. The reasons that this may be an issue for the PRC have been well documented (see, for example, Holz 2014). Scheibe (2003) devotes an entire paper to the calculation of the PRC's output gap. The author points out the many issues in estimating potential output for the PRC, ranging from the limited number of postreform observations, badly measured data, absence of proxies for capacity utilization or hours worked, no reliable inventory data, and significant structural changes.

This paper considers a production function output gap calculated by the Oxford Economics Global Economic Databank (Figure 2), given that this organization has access to data that are not widely available. This variable is estimated as follows: "We construct our measure of potential output bottom-up by looking at the inputs into the production function ([labor] supply, capital accumulation, and the components of [total factor productivity]). Subsequently, we benchmark this against actual GDP to a period where we feel the economy was

[4]More recently Zhang and Murasawa (2011, 2012) and Zhang et al. (2013) have estimated a measure of the output gap for the PRC based on a multivariate dynamic model.

Figure 2. **Production Function Output Gap**



Source: Oxford Economics. Global Economic Databank. http://www.oxfordeconomics.com/forecasts-and-models/cities/china-cities-and-regional-forecasts/overview (accessed January 2015).

operating at potential to ensure the level of actual and potential GDP at that moment is equal and the output gap is zero."[5]

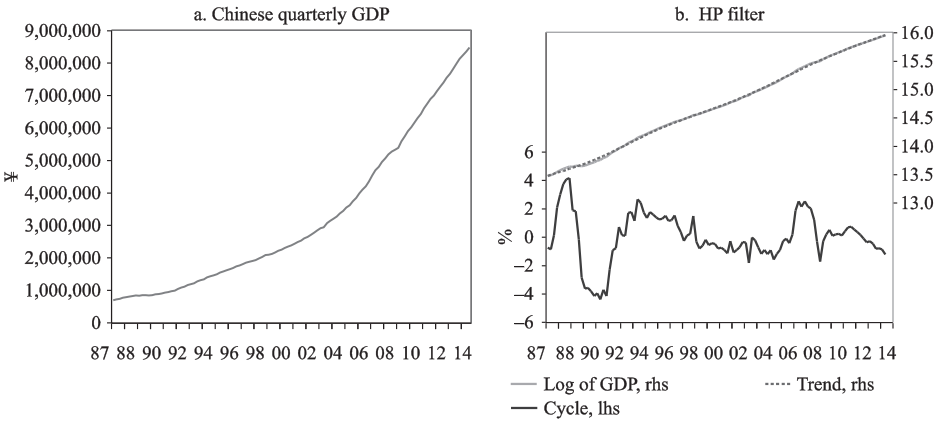
2. Filtering

A frequently used tool in macroeconomics is the Hodrick–Prescott (HP) filter, which decomposes actual output into a long-run trend and cyclical components. This statistical method does not use any information regarding the determinants of each of the components, but provides a useful approximation of potential output growth. While the time series approach is easy to implement, it suffers from the drawback that it provides no economic understanding of the sources of growth. Thus, it is arguably best seen as a complement to the more rigorous production function approach (Gerlach and Peng 2006). Therefore, we will calculate an HP filter output gap using GDP data from the PRC's National Bureau of Statistics to compare to Oxford Economics' estimations.

To get a complete comparison for as long a period as possible, we use the earliest available data and calculate an HP filter output gap from 1987 to 2014. The PRC's quarterly GDP data can be seen in Figure 3(a) and the HP filter applied to this series in Figure 3(b). The calculated output gap is presented in Figure 4.

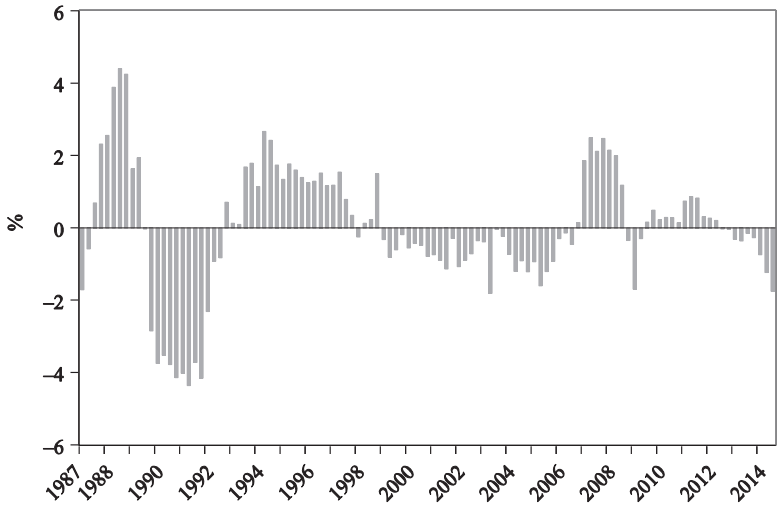
[5]This includes data on wages; labor; primary, secondary, and tertiary activities; employment; income and consumer spending; retail sales; and other series of importance. Oxford Economics, Global Economic Databank. http://www.oxfordeconomics.com/forecasts-and-models/cities/china-cities-and-regional-forecasts/overview (accessed January 2015).

Figure 3. **Hodrick-Prescott Filter of the PRC's GDP Data**



GDP = gross domestic product, HP = Hodrick-Prescott, PRC = People's Republic of China.
Sources: National Bureau of Statistics; and authors' calculations.

Figure 4. **Hodrick-Prescott Filter Output Gap**

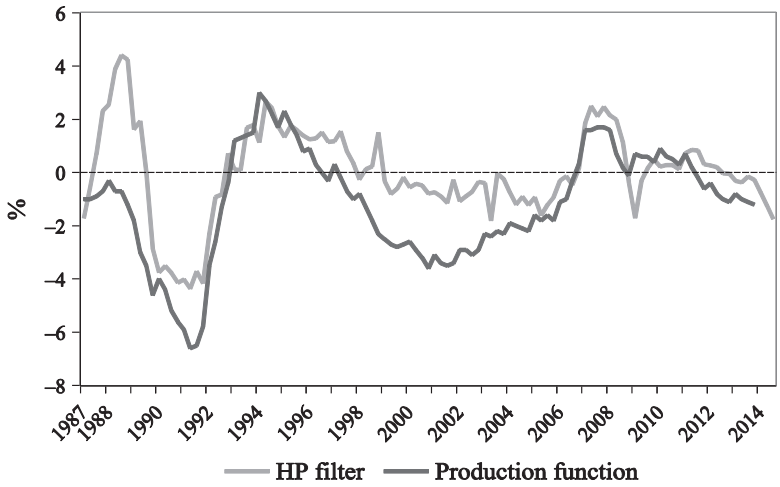


Sources: National Bureau of Statistics; and authors' calculations.

3. Comparison of Both Series

Both the production function output gap and the HP filter output gap are plotted together in Figure 5. There is a noticeable difference between the two in the 1987–1989 period: the HP filter estimation shows a highly positive output gap, while the production function gap shows a negative value. The significant difference in the HP filter estimation in this period may be explained by the arguments of Giorno,

Figure 5. **Comparison of the PRC's Output Gaps, 1987–2014**



HP = Hodrick-Prescott, PRC = People's Republic of China.
Sources: Oxford Economics. Global Economic Databank. http://www.oxfordeconomics.com/forecasts-and-models/cities/china-cities-and-regional-forecasts/overview (accessed January 2015); and authors' calculations.

Roseveare, and Van Den Noord (1995), who suggest the HP filter method often falls victim to an endpoint problem. In part, this reflects the fitting of a trend line symmetrically through the data. If the beginning and the end of the dataset do not reflect similar points in the cycle, then the trend will be pulled upward or downward toward the path of actual output for the first and last few observations. For example, for those economies that have been slower to emerge from a recession, an HP filter will tend to underestimate trend output growth for the current period. Other than this discrepancy, the two series seem to follow a similar pattern of output operating above or below potential in similar periods.

What is striking about both series is that despite GDP growth, which has averaged almost 10% since 1987, the PRC's output gap has remained negative for the majority of the review period. This point has also been made by the IMF (2012). This problem of excess capacity can be highlighted by examining both estimates of the PRC's output gap.[6] It is indicative of a growth model that has relied on high levels of investment and exports combined with surplus labor. In the past, the PRC's high levels of investment created capacity beyond its ability to consume. The excess capacity has often been absorbed outside its borders by the exceptionally strong global demand for the PRC's exports (IMF 2014). As the 2008–2009 global financial

[6]Several factors are believed to contribute to the problem of excess capacity in the PRC. These include very high rates of saving and investment, a massive transfer of unskilled labor from the agriculture to urban nonagriculture sectors, cheap labor costs, low levels of education, and low levels of technical innovation (Wang, Fan, and Liu 2008). In addition, there is the PRC's institutional and political environment, which often results in central and regional governments propping up largely inefficient state-owned enterprises.

crisis highlighted, however, the PRC can no longer rely on the same blistering level of demand for its exports that it enjoyed in the early and mid-2000s.

The similarity of these two techniques using two different datasets adds robustness to the use of the PRC's output gap in our empirical estimations. Given that the production function is often seen as the optimal methodology in estimating an economy's potential output, we use the production function estimate of potential output measure as calculated by Oxford Economics Global Economic Databank.

C. A Monetary Policy Index for the People's Republic of China

1. Unobserved Components Model

Quantifying unobserved variables is a common problem in empirical research. Often in macroeconomics, we come across variables that play an important role in theoretical models but which we cannot observe. Unobserved component models have been used in economics research in a variety of problems when a variable that is supposed to play some relevant economic role is not directly observable. While a particular variable may not be directly observable, the unobserved component model using a Kalman filter allows researchers to predict how this unobserved variable might be behaving.[7] For example, unobserved components have been used in modeling agents' reaction to permanent or transitory changes in the price level (Lucas 1976), modeling the credibility of the monetary authority (Weber 1992), and measuring the persistence (long-term effects) of economic shocks (Cochrane 1988). The statistical treatment of an unobserved components model is based on the SSM form. In the SSM, the unobserved components, which depend on the state vector, are related to the observations by a measurement equation. A transition equation then models the dynamics of the unobserved variables or states. While linear regression models use exogenous variables to distinguish the explained variation from the unexplained variation, SSMs rely on the dynamics of the state variables and the linkage between the observed variables and state variables to draw statistical inference about the unobserved state. This allows us to estimate the unknown parameters of the model. The Kalman filter is the basic recursion for estimating the state, and hence the unobserved components, in a linear SSM (Harvey, Koopman, and Sheppard 2004). The useful thing about the unobserved components model is that if the unobserved variable is closely linked with an observed variable, it is possible to predict the value of that variable from the observed values. The purpose of using this technique in this paper is to make inferences about the unobservable policy instruments that the PBOC carry out given a set of observable policy instruments.

[7] Additional information on this technique can be found in Cuthbertson, Hall, and Taylor (1992); Kim and Nelson (1999); and Commandeur and Koopman (2007).

We can categorize the monetary policy tools of the PBOC as either quantitative or qualitative:

- Quantitative monetary policy tools, often known as general tools, are the instruments used most often by central banks and monetary authorities in advanced economies. These include bank lending and deposit rates, reserve requirements, and open market operations. The quantitative instruments used in this paper were chosen based on information from various PBOC official publications. For example, "[the] monetary policy instruments applied by the PBOC include reserve requirement ratio, central bank base interest rate, rediscounting, central bank lending and deposit rate, open market operations, and other policy instruments specified by the State Council."[8]

- Qualitative monetary policy tools, described as selective tools, often involve direct administrative pressure on financial players to make them operate consistently with national needs (Geiger 2008). This style of institutional coercion is one of the PBOC's unique characteristics and it reflects the PRC's hierarchical order. It also makes the monetary policy reactions of the PBOC very difficult to quantify and model accurately. The most well-known of these instruments is window guidance, also known as moral suasion or jawboning.[9] Despite the word "guidance," which implies a voluntary aspect in the system, the PBOC has had a major influence on the lending decisions of financial institutions, especially the four state-owned commercial banks (Ikeya 2002).

A key consideration of this paper is how to quantify the latter of these two monetary policy tools; that is, how to link the unobserved variables (qualitative) to the observed variables (quantitative)? Let us suppose that the PRC's money supply (M2) changes in a way that would be consistent with a certain monetary policy response.[10] Let us also assume, however, that none of the standard quantitative policy instruments (e.g., interest rates, open market operations, and reserve requirement ratios) that we would expect to influence M2 cannot be held accountable for the deviations. It is, therefore, logical to assume that some unobserved qualitative variables might be responsible for changes in M2. Of course, this does not mean that all changes in M2 not explained by the measurement equation variables will be explained by this

[8]PBOC. Monetary Policy Instruments. http://www.pbc.gov.cn:8080/publish/english/979/index.html (accessed January 2015).

[9]There are several other direct control instruments that a central bank can use. These include credit controls (lending ceilings and floors) and prudential guidelines (informing commercial banks to exercise particular care in their operations in order that specified outcomes are realized).

[10]M2 is chosen because qualitative instruments are likely to be reflected onto the broad money supply (Petreski and Jovanovic 2013).

unobserved variable as there is probably a lot of noise in the M2 data. There is, however, likely to be very useful signal or noise-free data. The Kalman filter is, therefore, used to separate the best signal from the noise.

2. Setup of the Unobserved Components Model

First of all, we need to specify the quantitative instruments that will influence M2. The main quantitative policy instruments used by the PBOC are the base (discount) rate, reserve requirement ratios, and open market operations. Secondly, we include instruments based on the nature of the PRC's financial system. Since the PRC's banking and financial institutions are dominated by state-owned banks, any rate changes can be treated as a monetary policy response and so we include both the lending and deposit rates of these institutions. Finally, we need to include any other variable that will have a major influence on the level of M2. Therefore, we include changes in the level of real GDP as this will obviously affect M2 growth. Finally, we include the nominal effective exchange rate as the exchange rate is heavily managed and any deviation in its level will also affect growth in M2. While the renminbi was pegged to the US dollar without any movement between 1994 and 2005, the variable used, the nominal effective exchange rate, varies throughout the estimation period. Therefore, we can account for the effect that these nominal appreciations and depreciations, caused by changes in the exchange rate policy or regime, had on the growth of M2.

Equation 3 and 4 represent the measurement and transition equations, respectively. The quarterly change in M2 is chosen as the dependent variable in the measurement equation because, as mentioned, qualitative instruments are likely to be reflected onto broad money. ΔM2 is then expressed as a function of both the quantitative and the qualitative monetary policy instruments used by the PBOC. The transition equation then models the unobservable qualitative instruments as a first-order autoregressive process (AR[1]). The qualitative instrument series is obtained by a Kalman filter estimation of this money demand function. The two equations are written in the following forms:

Measurement equation

$$\Delta M2 = \beta_1 + \beta_2\, exchange\ rate + \beta_3\, base\ rate + \beta_4\, reserve\ requirement + \beta_5\, lending\ rate + \beta_6\, deposit\ rate + \beta_7\, GDP + \beta_8\, Qual + \epsilon_{t1} \quad (3)$$

Transition equation

$$Qual = \beta_9\, Qual(-1) + \epsilon_{t2} \quad (4)$$

The measurement equation links the quantitative variables ($\beta_3\, base\ rate + \beta_4\, reserve\ requirement + \beta_5\, lending\ rate + \beta_6\, deposit\ rate$) and changes in the exchange rate and GDP ($\beta_2\, exchange\ rate + \beta_7\, GDP$) to an unobserved state variable

(β_8 *Qual*).[11] The transition equation then describes the dynamics of this qualitative instrument.[12] This *Qual* variable in both Equations 3 and 4 is the vector of the unobserved variables and describes how these variables evolve over time. The error terms e_{t1} *and* e_{t2} are the monetary policy shock and shocks to the qualitative instruments, respectively. The setup of this unobserved component model assumes that the only variable affecting the quarterly growth rate of M2 that can have an AR(1) structure is the unobserved variable and treats all other factors as shocks. While using this assumption to define our series for the qualitative variable may at first seem slightly naive, it is justified for the simple reason that the key variables that may have an AR(1) structure and still effect changes in M2 have already been included in the measurement equation. Therefore, it is logical to assume that the only important variable that remains for the quarterly change in M2 is this qualitative variable. The qualitative variable is intended to capture PBOC actions such as window guidance, bank directives, credit guidance, and other instructions that are widely regarded to be very important to the PRC's banking sector. We expect that the qualitative variable would influence M2 as it involves the central bank persuading commercial banks to take certain steps without the PBOC making any changes to benchmark rates.

3. Estimating the Qualitative Variable

The results of the estimations are as follows:

Measurement equation

$$\Delta M2 = 7.5^{***} - 0.04\,\textit{exchange rate} + 0.32\,\textit{base rate} + 0.10\,\textit{reserve requirement} - 1.4^{*}\,\textit{lending rate} + 0.95^{***}\,\textit{deposit rate} + 0.05\,GDP + \textit{Qual}^{13} \quad (5)$$

Transition equation

$$\textit{Qual} = -0.02\,\textit{Qual}(-1) \quad (6)$$

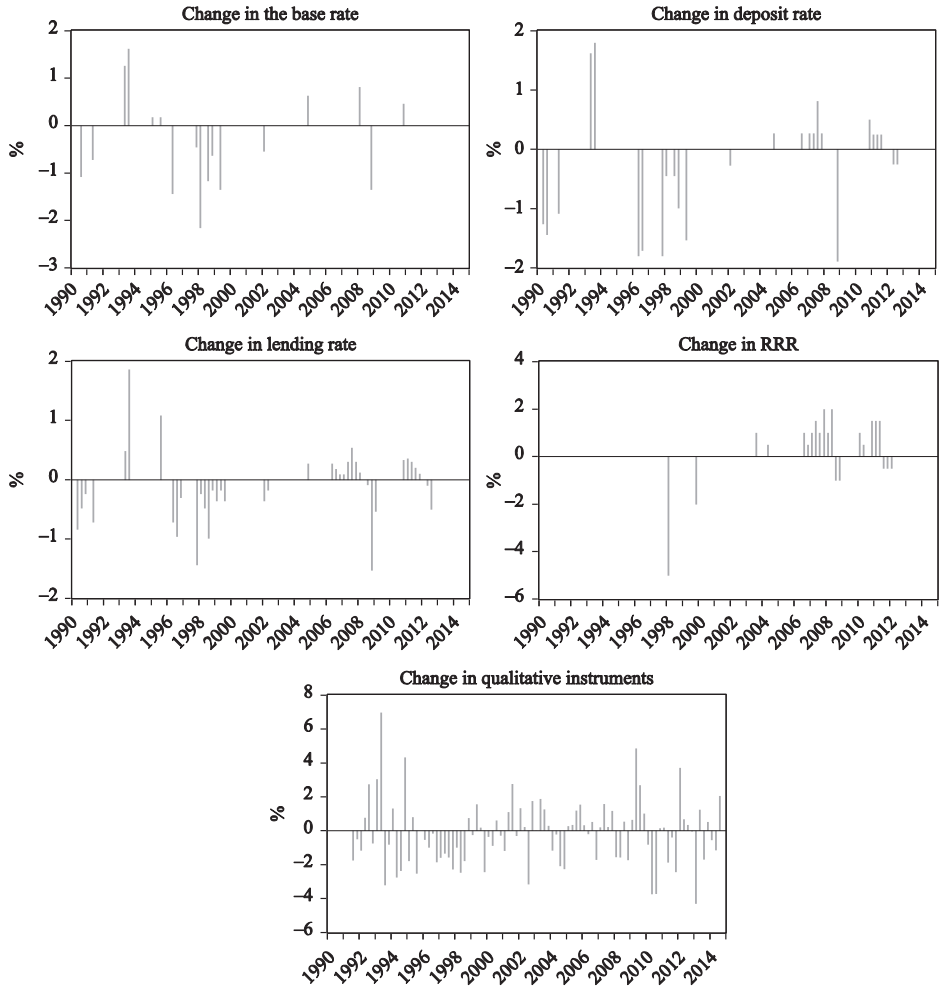
The measurement equation results show that while the GDP growth rate and changes to the exchange rate are correctly signed, their coefficients are not significant. The base rate and the reserve requirement ratio are insignificant and also incorrectly signed. In fact, of all the monetary policy tools included in the equation, only the deposit rate is correctly signed and significant. This suggests that for the

[11] Note the omission of the open market operations variables. The variable for the open market operations variable moved almost exactly with the base (discount) rate. They deviated at the same periods and by the same magnitude; therefore, all the dynamics are already captured by the base rate.

[12] The starting values for the parameters in the measurement equation were chosen from an ordinary least squares (OLS) regression, which is the standard procedure for an estimation of this type.

[13] ***, **, and * denote significance at the 1%, 5%, and 10% level of significance, respectively.

Figure 6. **PBOC Monetary Policy Index Variables**



PBOC = People's Bank of China, RRR = reserve requirement ratio.
Sources: National Bureau of Statistics. http://www.stats.gov.cn/english/; International Monetary Fund. International Financial Statistics. http://data.imf.org/?sk=5DABAFF2-C5AD-4D27-A175-1253419C02D1 (both accessed January 2015); and authors' calculations.

most part the quantitative variables have had a limited impact on the PRC's money supply. This equation obviously suffers from multicollinearity problems, however, and so the interpretation of its results must be treated with caution.

The transition equation on the other hand will give the prediction of the qualitative instruments used by the PBOC. Technically speaking, the transition equation identifies the latent AR(1) that affects growth in M2. The predicted series calculated from the estimation can be seen in the bottom center panel of Figure 6 (Changes in Qualitative Instruments). This series should, broadly speaking,

Table 2. **Coefficient of Variance of Policy Instruments**

Index	Deposit	Lending	Base	RRR	Qualitative
MPI_t	0.20	0.09	0.16	0.12	0.43

MPI = Monetary Policy Index, RRR = reserve requirement ratio.
Note: The coefficients have been normalized.
Source: Authors' calculations.

correspond to the selective monetary policy actions of the PBOC. As a simple example, the marked increase and decline in the 1992–1995 period may be accredited to Deng Xiaoping's southern tour. The spike in the 2008–2009 period may have captured the stimulus package the PBOC undertook to mitigate the domestic impacts of the global financial crisis. From a simple observation of the series, it would appear that our qualitative variable measure has succeeded in capturing some of the important "unobservable" in the PRC's monetary policy movements.

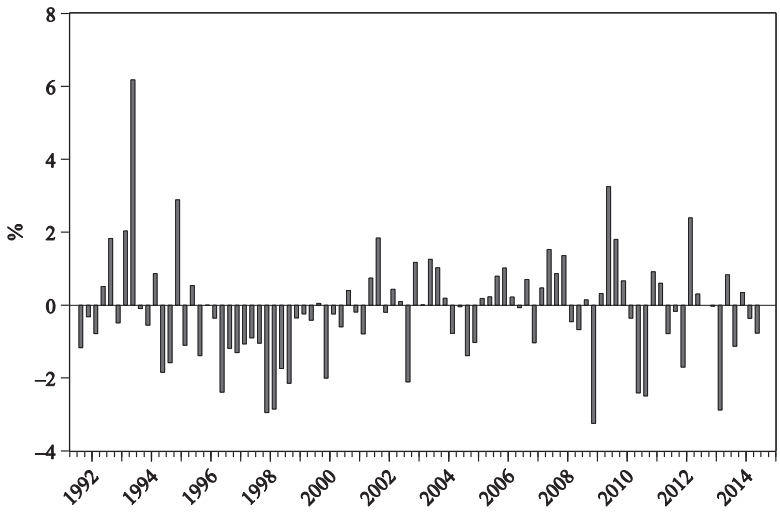
4. Calculating the Index

Having obtained an estimated series of the qualitative variable, the monetary policy index can then be constructed. Firstly, the coefficient of variance of the five instruments, both qualitative and quantitative, is calculated and their sum normalized to unity.[14] The coefficient of variance is a statistical measure of the dispersion of data points in a data series around the mean. It is a useful statistic for comparing the degree of variation from one data series to another even if the means are drastically different from each other. This technique allows us to examine and compare the degree of variation of the five series. The coefficient of variance for the five variables can be seen in Table 2. We can see that the main monetary policy tools mentioned by the PBOC—deposit rate, lending rate, discount rate, and reserve requirement ratio—play a relatively minor role and seem to change infrequently when compared to our qualitative instrument. The addition of the qualitative instrument variable clearly shows the importance of its role as a monetary policy tool.

This is confirmed by examining the changes in all policy variables (Figure 6), which show that the qualitative instrument variable changes far more frequently than the other four quantitative variables. The final MPI is then calculated as a weighted average of the changes in the five policy instruments, using the coefficient of variance values as weights (Table 2). Figure 7 plots the final MPI that will be used in the estimations that follow. An increase in this index corresponds to an expansionary monetary policy stance and a decrease to a contractionary stance. This is due to the setup of the weightings of each of the variables. Therefore, we would expect to see a positive sign on the monetary policy reaction coefficient in the IS curve estimation.

[14]The five instruments are the four quantitative variables (deposit rate, lending rate, base rate, and reserve requirement ratio) and the estimated qualitative variable.

Figure 7. **Calculated Monetary Policy Index**



Source: Authors' calculations.

V. Estimations and Results

A. Standard Ordinary Least Squares Estimation

Table 3 reports the results of the traditional IS curve equation for the PRC that uses a standard single policy variable (lending rate) as a measure of the monetary policy stance of the central bank. Both a forward-looking (Equation 1) and backward-looking (Equation 2) IS curve are estimated. While these are the specifications most often used to examine monetary policy transmission in advanced economies, the literature has suggested that they may not provide an accurate representation of the monetary policy transmission channel in the PRC. The left-hand column of Table 3 provides the results of the forward-looking IS curve. The findings seem to support the arguments made in section III that forward-looking transmission equations of this kind perform poorly when tested empirically. First of all, the real interest variable, $i_t - E_t(\pi_t)$, is incorrectly signed and only significant at the 10% level. The demand shock, represented as a change in exports, is also insignificant and incorrectly signed. Finally, the estimations fail to satisfy tests for both autocorrelation and stability.[15] The center column of Table 3 provides the results of the backward-looking IS curve (Equation 2). This specification seems to provide a better fit for the data. The lag of the output gap is large and highly significant, indicating that shocks to the output gap are quite persistent. The real interest rate is correctly signed and highly significant, which suggests that the lending rate set

[15]This can be seen by examining the LM F Statistic and the SupF Statistic.

Table 3. **IS Curve Estimation—OLS Estimation, Q2 1991–Q3 2014**

Variable	Forward-Looking IS Curve (1)	Backward-Looking IS Curve (2)	Monetary Policy Index IS Curve (7)
	Dependent Variable: PRC Output Gap, $\bar{y}_t$		
Constant	−0.01	0.01***	−0.01
a	(0.01)	(0.00)	(0.01)
Output gap lag	—	0.90***	0.98***
$\bar{y}_{t-1}$		(0.03)	(0.03)
Output gap expect.	1.02***	—	—
$\bar{y}_{t+1}$	(0.03)		
Real interest rate (Lending)	0.03*	−0.06***	—
$i_t - E_t(\pi_t)$	(0.02)	(0.01)	
Monetary Policy Index	—	—	0.12**
MPI_t			(0.04)
Demand shock (Exports)	−0.01	−0.01	0.01***
v_t	(0.11)	(0.10)	(0.01)
R^2	0.93	0.94	0.94
LM F-Stat	4.46**	2.26	2.11
SupF-Stat	28.12***	14.51	17.39***
	(Q4 1994)	(no break)	(Q4 1994)

HAC = heteroscedasticity and autocorrelation-consistent, IS = Investment–Saving, OLS = ordinary least squares, PRC = People's Republic of China.
Notes: *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance. HAC standard errors are in parentheses.
Source: Authors' calculations.

by the PBOC did have an effect on the real economy. While the coefficient of 0.06 indicates that the magnitude of this effect is quite small, it can be examined further by estimating the standard deviation (SD) of variables.[16] This will give a more precise indication of the magnitude of the relationship between monetary policy and the real economy. A 1% SD in the interest rate results in a 0.12% change in the output gap. The effect of a shock to demand, represented in this paper as a change in exports, has no significant effect on the output gap during the estimation period. The presence of structural breaks can also be tested by applying the Quandt–Andrews SupF statistic (Quandt 1960 and Andrews 1993). Table 3 shows that the model passes the tests for structural breaks, which suggests that this standard IS curve for the PRC is characterized by a stable and linear relationship. This is an interesting finding and is at odds with the majority of research in the area. The result suggests that a standard IS curve may be an appropriate model for examining the monetary policy transmission channel in the PRC. There are explanations one can offer as to why the magnitude of this relationship is quite small. The underdevelopment of the banking system, market segmentation, and the ineffectiveness of the credit channel,

[16]These are calculated throughout the paper using the summary statistics that are provided in the Appendix. The SD is calculated by multiplying the coefficient given for the independent variable by the SD of that variable divided by the SD of the dependent variable.

as well as the fact that the PBOC has also relied on many different tools in the conduct of monetary policy, are all possible explanations.

As the PBOC has been known to use a variety of different policy instruments, an index representing these may give a better and more accurate representation of the PRC's monetary policy stance. The augmented IS curve model, estimated using the MPI that was estimated in section IV.C, then takes the following form:

$$\bar{y}_t = a + b(\bar{y}_{t-1}) + c(MPI_t) + dv_t + \varepsilon_t \quad (7)$$

The estimation of this augmented IS curve can also be seen in Table 3 (right-hand column).

Again, the persistence of a shock to the output gap is very high. The results, a coefficient of 0.12, seem to indicate that changes in this combined index have a stronger effect on the real economy than the interest rate. The positive sign suggests that an increase in the index corresponds to looser monetary policy and a decrease to tighter monetary policy. As before, we can examine more rigorously the relationship between the output gap and the MPI by examining the SD of the variables. A 1% SD in the MPI leads to only a 0.08% change in the output gap, a change that is actually smaller than that calculated by the interest rate IS curve. The validity of the results are, however, compromised by the presence of a structural break. This is observed by the highly significant value of the SupF test in Table 3. In an attempt to remedy this problem, the next section of the paper estimates the MPI–IS curve using models that allow for structural breaks and switching between different states or regimes.

B. Breakpoint Model

The standard linear regression model assumes that the parameters of the model do not vary across observations. Despite this assumption, structural change, which is the changing of parameters at dates in the sample periods, plays an empirically relevant role in applied time series analysis. This is particularly true of economies such as the PRC that have experienced reform and institutional change. With this in mind, a linear regression model that is subject to structural change is estimated. There has been a large volume of work targeted at developing testing and estimating methodologies for regression models that allow for change. The seminal work of Chow (1960) and Quandt (1960) developed the testing procedure for structural changes in a time series at a single specified (known) break date. Bai and Perron (1998, 2003) developed this technique further and attempted to develop methods that allow for estimation and testing of structural change at unknown break dates.[17] An important feature of this test is that it allows us to test for multiple breaks

[17] Details of the multiple breakpoint regression model were sourced from Bai (1997); Bai and Perron (1998); Demers (2003); and Carlson, Craig, and Schwarz (2000).

Table 4. **Monetary Policy Index IS Curve with Multiple Breakpoints, Q2 1991–Q3 2014**

Variable	Period 1 (Q2 1991–Q4 1994)	Period 2 (Q1 1995–Q3 2014)
Dependent Variable: PRC's Output Gap, $\bar{y}_t$ (breakdate: Q4 1994)		
Constant	−0.01	0.01*
a	(0.01)	(0.01)
Output gap lag	0.99***	0.96**
$\bar{y}_{t-1}$	(0.04)	(0.03)
Monetary Policy Index	0.24***	0.07*
MPI_t	(0.08)	(0.04)
Demand shock (Exports)	0.04*	0.01
v_t	(0.04)	(0.02)

HAC = heteroscedasticity and autocorrelation-consistent, IS = Investment–Saving, PRC = People's Republic of China.
Notes: *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance. HAC standard errors are in parentheses.
Source: Authors' calculations.

at unknown dates. It is well documented that the effects of financial liberalization and economic reform are difficult to model using standard ordinary least squares (OLS) regressions, often due to the structural breaks that such events can cause in the time series (Blangiewicz and Charemza 1999). The Bai–Perron procedure is useful in such a case as it allows the user to find the number of breaks implied by the data and estimate the timing of the breaks and the parameters of the processes between breaks. The methodology can be used to estimate multiple structural changes in a linear model estimated by OLS. It treats the number of breakpoints and their locations as unknown.

Applying this procedure to the augmented IS curve with the calculated policy index, this gives us the following IS curve equation with m breaks:

$$\bar{y}_t = a_1 + b_1\bar{y}_{t-1} + c_1\, MPI_t + d_1 v_t + \varepsilon_t \quad t = 1, \ldots\ldots, T_1 \tag{8}$$

$$\vdots$$

$$\bar{y}_t = a_m + b_m\bar{y}_{t-1} + c_m\, MPI_t + d_m v_t + \varepsilon_t \quad t = T_{m+1}, \ldots\ldots, T \tag{9}$$

where the breakpoints $(T_1, \ldots\ldots T_{m+1})$ are treated as unknown. The Bai–Perron estimation is based upon OLS estimates of a_i, b_i, c_i, and d_i.

The results of the multiple breakpoint regression, which can be seen in Table 4, confirm the presence of a structural break in Q4 1994. In Q2 1991–Q4 1994 (Period 1), the lag of the output gap is very high at 0.99 and significant at the 1% level. This indicates that shocks to the output gap are very persistent in this period. The index representing the monetary policy changes of the PBOC is highly significant in Period 1 with a coefficient of 0.24. A 1% SD in the policy index results in a 0.15%

change in the output gap. Finally, the demand shock is significant (if only at the 10% level) in this period, but has a small magnitude with a coefficient of 0.04. Examining the SD, a 1% shock to demand in Period 1 shows it causes a 0.13% change in the output gap.

In Q1 1995–Q3 2014 (Period 2), the lagged coefficient of the output gap is again highly significant at 0.96. The MPI is only significant at the 10% level with a coefficient value of 0.07. Again, we can evaluate the magnitude of the relationship by examining the effect of a 1% SD on the output gap. A 1% change in the policy index in this period leads to only a 0.05% deviation in the output gap. There is no significant effect of the demand shock on the output gap in Period 2.

C. Markov Switching Model

While the estimations in section V.B provide a better insight into the monetary policy transmission process in the PRC than the standard linear model, the breakpoint regression is limited in that it does not allow us to switch between different regimes or states. Many economic time series occasionally exhibit dramatic breaks in their behavior that are associated with events such as financial crises or abrupt changes in government policy (Hamilton 2005). The PRC, in particular, has experienced tremendous structural change in recent decades associated with the gradual opening of the economy. Prices have been liberalized, trade has increased extensively, companies have been privatized, and the economy has been transformed from one that was centrally planned prior to 1978 to a market economy (Brandt and Rawski 2008). The PRC has also experienced several economic shocks, some of which were related to policy measures to liberalize the economy (Gerlach and Peng 2006). The breaks in the time series associated with these events make linear models inappropriate for analyzing macroeconomic variables over time. To fully capture nonlinearity, the PRC's monetary policy transmission channel is examined using the MS model of Hamilton (1989, 1990, 1994). This technique has been used extensively to examine monetary policy transmission in advanced economies such as the United Kingdom, the US, and the eurozone. Dolado, Maria-Dolores, and Ruge-Murcia (2005); Peersman and Smets (2001); and Aragón and Portugal (2009) have all carried out similar studies for advanced economies, but the technique has seldom been applied to the PRC or other emerging market economies. This gives us a unique opportunity to examine any asymmetry or nonlinearity in the PRC's monetary policy transmission channel. The MS model is so called because the switching mechanism is controlled by an unobserved state variable, s_t, that follows a first order Markov chain process. An interesting feature of the MS model is that the filtered probabilities can be interpreted as the agent's belief that the economy is in one of the possible states that describe the economy. It is also a very useful technique as the unobserved or latent state variable can be linked (or at least possibly linked) to an observable event, policy, or characteristic. Another key point is that the

MS model is relatively easy to implement because it does not assume any a priori knowledge of an arbitrary time period or event. Instead, the regime classification in this model is probabilistic and determined by the data (Kuan 2002).

By fitting the linear IS curve equation to the MS framework, we get the following:[18]

$$\bar{y}_t = a_{st} + b_{st}(\bar{y}_{t-1}) + c_{st}(MPI_t) + dv_{t_{st}} \tag{10}$$

where $e_t \sim$ i.i.d. $N(0, \sigma^2_{e,st})$ and with unobserved state s_t, which is assumed to follow a Markov chain of order 1 with transition probabilities p_{ij}. The transition probability p_{ij} gives the probability that state i will be followed by state j.

$$P_{ij} = \Pr[s_t = j \mid s_{t-1} = i], \quad \sum_{i-1}^{M} p_{ij} = 1, \quad \forall i, j = 1, \ldots..M \tag{11}$$

This is often then written in an *(M x M)* matrix P, called a transition matrix:

$$\mathrm{P} = \begin{bmatrix} p_{11} & p_{21} & \cdots & p_{M1} \\ p_{12} & p_{22} & \cdots & p_{M2} \\ \vdots & \vdots & \cdots & \vdots \\ p_{MM} & p_{2M} & \cdots & p_{MM} \end{bmatrix} \tag{12}$$

The row i, column j element of P is the transition probability p_{ij}. To demonstrate, in the above matrix (12), the row 2 column 1 element gives the probability that State 1 will be followed by State 2. For example, at time t the state of the economy s_t is classified as having either a positive output gap ($s_t = 1$) or a negative output gap ($s_t = 2$). In our estimation, we assume that the model gives us a probability of 95% of being p_{11} and 5% of being p_{21}. What these values tell us is that if the economy is in a state of a negative output gap in the previous period, it tends to stay in this state at a very high probability of 95%. On the other hand, the probability of being in a negative output gap state in the previous period and switching to a positive output gap state is just 5%.

The estimation of the model depends on maximum likelihood. The maximization of likelihood function of the model requires an iterative estimation technique to obtain estimates of the parameters of the model and the transition probabilities.[19] With the parameters identified, it is then possible to estimate the probability that the variable of interest is following a particular regime. It is also

[18] In the interest of robustness, estimations were carried out using both the MS estimation function in Eviews 8 and the MS_Regress_Fit package developed by Perlin (2012) in Matlab. The results were very similar.

[19] For more detail on this technique and the maximum likelihood see Hamilton (1989, 1994) and Kim and Nelson (1999).

Table 5. **Monetary Policy Index IS Curve with Markov Switching Model, Q2 1991–Q3 2014**

Variable	State 1	State 2
Dependent Variable: PRC's Output Gap, $\bar{y}_t$		
Constant	−0.01***	0.01***
a	(0.01)	(0.01)
Output gap lag	0.91***	0.70***
$\bar{y}_{t-1}$	(0.03)	(0.04)
Monetary Policy Index	0.05	0.25***
MPI_t	(0.05)	(0.06)
Demand shock (Exports)	0.01***	0.04***
v_t	(0.01)	(0.01)
p_{11}	0.96	
p_{12}	0.04	
p_{21}		0.11
p_{22}		0.89
Duration of state	32.9 quarters	8.8 quarters

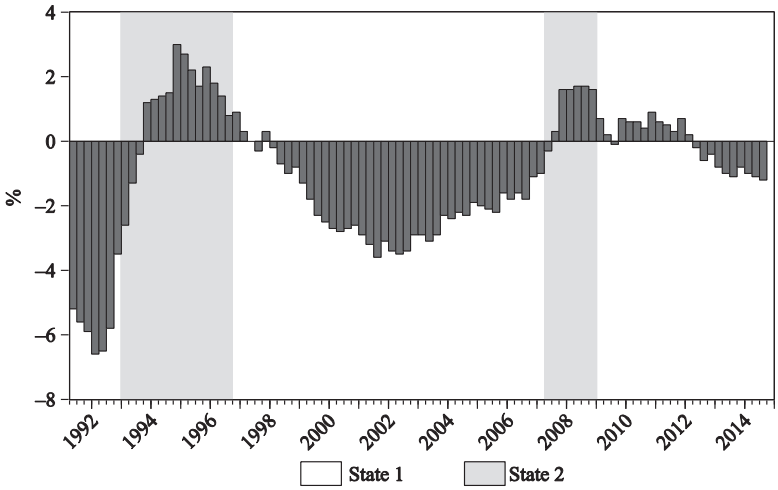
HAC = heteroscedasticity and autocorrelation-consistent, IS = Investment–Saving, PRC = People's Republic of China.
Notes: *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.
HAC standard errors are in parentheses.
Source: Authors' calculations.

possible to derive the smoothed state probabilities that indicate the probability of being in a particular regime or state. For example, the MS model may highlight the effectiveness of the PBOC's monetary policy depending on whether the PRC's economy is operating above or below potential (positive or negative output gap). Before estimating the MS–IS curve, the number of states or regimes to be included in the model must be chosen. As there are often relatively few transitions among states, it is difficult to estimate strictly exogenous explanatory variables accurately. For this reason, most applications assume only two or three states (Hamilton 2005). Tests for both a two-state and three-state MS–IS curves were carried out. The three-state specification was rejected against the two-state specification since the data points were detected only in the first and second states.

The results of the MS estimation of the IS curve can be seen in Table 5 and the two identified states plotted against the output gap can be seen in Figure 8.

In State 1, the autoregressive coefficient of the output gap is high at 0.91. This indicates that shocks to the output gap are quite persistent (i.e., output will increase if output was high in the previous period). The MPI has no significant effect on the output gap in this state. The effect of the demand shock (change in exports), while significant, is very small. We can examine the relationship of the significant independent variables to the output gap further by examining a 1% SD in the demand shock, which has only a 0.09% effect. By examining both Figure 8 and the summary statistics in the Appendix we can see that State 1 can be mostly

Figure 8. **Output Gap with Regime Classification**



Sources: Oxford Economics. Global Economic Databank. http://www.oxfordeconomics.com/forecasts-and-models/cities/china-cities-and-regional-forecasts/overview (accessed January 2015); and authors' calculations.

characterized by a period when output was operating below potential (i.e., negative output gap).[20]

In State 2, the persistence of shocks to the output gap is again high but has decreased from State 1. The MPI is correctly signed and highly significant with a coefficient of 0.25. This indicates that changes to the various policy instruments used by the PBOC had a significant effect on the real economy. The demand shock (change in exports) is also highly significant with a coefficient of 0.04. A 1% SD in the MPI leads to a 0.33% change in the output gap. The effect of a demand shock is much stronger in State 2 than in State 1. A 1% SD in the PRC's exports leads to a 0.44% change in the output gap. Figure 8 and the summary statistics in the Appendix indicate that State 2 can be described as a period when output was mostly operating at or above potential (i.e., neutral or positive output gap).

D. Summary of Results

From the results of the various estimations in this section, several important characteristics of the monetary policy transmission channel in the PRC have been identified. Contrary to the majority of the literature in the area, the results find that a single policy instrument—the lending rate set by the PBOC—can have a significant effect on the real economy. However, the magnitude of this relationship between the interest rate and the output gap is small. The results also found that the traditional

[20] As mentioned, this seems unusual for an economy that has grown at 9% per year. The issue of the PRC's excess capacity is discussed in detail in IMF (2012).

IS curve specification was linear and stable over the estimation period. An IS curve estimated using a composite index of the policy tools employed by the PBOC, including a measure of qualitative instruments, does not improve on the standard model. However, this specification was found to contain structural breaks.

An IS curve using the breakpoint model of Bai and Perron (1998, 2003) and an MPI consisting of both quantitative and qualitative policy instruments was then estimated. The results suggested that there was a breakpoint in Q4 1994. This breakpoint corresponds to key institutional changes and reforms in the PRC's economy. These include reforms to the banking sector; reforms regarding price liberalization; and, crucially, the adoption of the dollar peg exchange rate regime. These events therefore seem to have had a distinct effect on the PRC's monetary policy transmission channel. During the period prior to this breakpoint (Period 1: Q2 1991–Q4 1994), the MPI exerted a significant influence on the real economy. In the period after the breakpoint (Period 2: Q1 1995–Q3 2014), the same instruments played a less significant role in changes to the level of output. This is an important finding as Period 2 included continued reform of the banking and finance sector which, in theory, should have improved both the transmission channel and mechanisms of monetary policy, as well as the influence and autonomy of the PBOC. A possible explanation for this counterintuitive finding is the adoption of the dollar peg.[21] It is possible that the maintenance of this quasifixed exchange rate regime has served to hinder the ability of the PBOC to influence the real economy through the monetary policy transmission channel.

The final model estimated was an MS–IS curve. This model differs from the breakpoint model in that it allows switching between states. It classified the PRC's economy into two states. The majority of the estimation period is characterized by State 1, in which the MPI had no significant effect on the output gap. This state is mostly characterized by periods of below potential output (i.e., negative output gap). State 2, on the other hand, is characterized by mostly positive output gaps. The index for PBOC monetary policy changes was highly significant in this state. These results suggest that monetary policy in the PRC is much more effective when output is stronger relative to potential (operating at or above potential) than when it is weaker relative to potential (operating below potential). This finding has similarities to the "pushing on a string" hypothesis, which states that when the economy is weak (operating below its potential level), a central bank can do little to remedy the situation.[22] The high significance of the PRC's growth in exports in affecting whether the economy is operating above potential is also an important finding. For

[21] While the dollar peg, introduced in 1994, was officially abandoned in 2005, Morrison (2012) argues that the PRC's exchange rate mechanism remains, in practice, a tightly managed currency peg against the US dollar. In July 2015, the Financial Times reported that despite reform progress since 2005, intervention remains a daily reality (Wildau 2015).

[22] This metaphor, attributed to John Maynard Keynes, maintains that using monetary policy to fight a severe recession is like pushing on a piece of string (Blyth 2012).

many years, the PRC's high levels of investment created capacity beyond its ability to consume. This excess capacity was often absorbed outside its borders given the exceptionally strong global demand for the PRC's exports (IMF 2014). Therefore, our results would seem to emphasize the reliance of the PRC on exports in closing the gap between potential and actual output.

VI. Robustness Tests

In this section, we undertake robustness tests to add reliability and credence to the findings of both our breakpoint model and our MS model.

A. Breakpoint Model

The results of our breakpoint model found that prior to 1994, the index calculated to model changes in the PBOC's monetary policy exerted a significant influence on the real economy. However, in the period after the breakpoint date (Q1 1995–Q4 2014), the same instruments played less of a significant role in changes to the level of output. This result is surprising as the post-1994 period was characterized by historic monetary reforms toward a more modernized and financially liberated monetary system. We suggested that the PRC's controversial exchange rate regime may have served to hinder the ability of the PBOC to influence the real economy through the monetary policy transmission channel. This theory can be tested empirically by estimating a simple monetary policy reaction function.[23] Along with the standard monetary policy rule variables of the inflation and output gap, we include the nominal effective exchange rate as a target variable. The monetary policy reaction function, therefore, takes the following form:

$$MPI_t = a - b(\pi_{t-1} - \pi_t^*) - c(\bar{y}_{t-1}) - d\,\Delta neer_t + \varepsilon_t \tag{13}$$

As before, MPI_t is our calculated monetary policy index, $\pi_{t-1} - \pi_t^*$ is the inflation gap (inflation rate minus the inflation target), $\bar{y}_t$ is the output gap, and $\Delta neer_t$ is the change in the nominal effective exchange rate.[24] We then estimate this reaction

[23] As in our IS curve estimations, the interest rate is replaced with our MPI.

[24] All variables in Equation 13 were found to be I(0) and available by request. For the inflation gap variable ($\pi_{t-1} - \pi_t^*$), the Consumer Price Index inflation rate is available from the PRC's National Bureau of Statistics. An official target is also available from various publications at http://english.gov.cn/archive/. For the exchange rate target, changes in the nominal effect exchange rate are used. The nominal effective exchange rate is defined in foreign currency unit per renminbi (i.e., an increase in this variable corresponds to an appreciation of the renminbi). These data are available in the IMF's *International Financial Statistics*. As mentioned in section IV, the setup of the MPI implies that an increase corresponds to an expansionary monetary policy action. This changed the sign of the monetary policy response coefficient from minus to plus in our IS curve equation. Similarly, an increase in inflation or output over its target, potential, or natural level will lead to a contractionary monetary policy reaction. Therefore, we would expect to see negative signs for both the inflation and output gap coefficients.

Table 6. **Two-Period OLS Monetary Policy Reaction Function**

Variable	Period 1 (Q2 1991–Q4 1994)	Period 2 (Q1 1995–Q3 2014)
Dependent Variable: Monetary Policy Index, MPI_t		
Constant	−0.03	−0.01
a	(0.01)	(0.01)
Inflation gap	0.29	0.04
$\pi_{t-1} - \pi_t^*$	(0.19)	(0.06)
Output gap	−0.67*	−0.10
$\bar{y}_{t-1}$	(0.35)	(0.08)
Exchange rate	−0.01	−0.18***
$\Delta neer_t$	(0.06)	(0.07)
R^2	0.28	0.14
DW-Stat	2.10	1.70

HAC = heteroscedasticity and autocorrelation-consistent, OLS = ordinary least squares.
Notes: *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance. HAC standard errors are in parentheses.
Source: Authors' calculations.

function before and after the breakpoint in 1994. The results, which are presented in Table 6, are interesting.

First of all, the inflation gap is incorrectly signed and insignificant across both time periods, suggesting that it does not appear to be an important factor in the monetary policy response of the PBOC across the entire estimation period. This is in line with Mehrotra and Sánchez-Fung (2010), who find the same result over a similar period (1994–2008). The authors of this paper argue that as the inflation gap was mostly negative in their estimation period, with the exception of brief periods in 1994/1995 and 2008, inflationary pressures may not have been a major concern for the PBOC. What is perhaps most interesting is that the output gap is correctly signed and significant in Period 1, if only at the 10% level, while the exchange rate is not significant. In Period 2, however, the coefficient of the output gap has decreased substantially and is no longer significant, while changes in the exchange rate have now become highly significant. This switch from a policy index that was responsive to deviations in output from its natural level to deviations in the level of the renminbi exchange rate seems to verify the results and interpretation of our breakpoint model. In other words, the PBOC's exchange rate policy of maintaining the renminbi at a desired level may have hindered the appropriate response to deviations in the level of output.

B. Markov Switching Model

We can also test the results of our MS model. The main finding of our model was that the PRC's monetary policy is more effective when output is operating above

Table 7. **Monetary Policy Transmission with Positive and Negative Output Gaps, Q2 1991–Q3 2014**

Variable	Negative Output Gap (14)	Positive Output Gap (15)
Dependent Variable: PRC's Output Gap		
Constant	−0.01	0.01
	(0.01)	(0.01)
Output gap lag	0.98***	0.88***
	(0.05)	(0.03)
Monetary Policy Index	0.13***	0.11**
	(0.05)	(0.06)
Demand shock (Exports)	0.01	0.01**
	(0.01)	(0.01)

HAC = heteroscedasticity and autocorrelation-consistent, PRC = People's Republic of China.
Notes: *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance. HAC standard errors are in parentheses.
Source: Authors' calculations.

potential and less effective when operating below potential. The MS estimations detected two states, which we labeled State 1 and State 2. While these states were roughly defined as mostly operating below (State 1) or above (State 2) potential, it is obvious from Figure 8 that not all positive and negative periods correspond exactly to the states detected by the model. Therefore, we can undertake a much more simple, if not arbitrary, examination of this dynamic. This is done by running two separate linear regressions:

$$\bar{y}_{tNEGATIVE} = a + b(\bar{y}_{t-1}) + c(MPI_t) + d\,v_t + \varepsilon_t \tag{14}$$

$$\bar{y}_{tPOSITIVE} = a + b(\bar{y}_{t-1}) + c(MPI_t) + d\,v_t + \varepsilon_t \tag{15}$$

These correspond exactly to periods of positive and negative output gaps.[25] While this technique lacks many of the advantages of our MS estimation (section V.C), it is nonetheless a useful robustness check of the validity of our findings and interpretations. The results are presented in Table 7 below. The coefficient of the output gap does not differ greatly across the positive and negative output gap periods, with coefficients of 0.11 and 0.13, respectively. In fact, contrary to our MS estimation, the reaction appears to be stronger, if only marginally, in the negative output gap period. However, as mentioned in section V.A, it is important to examine the relationship in terms of the SD of variables. Using the summary statistics in the Appendix, we find that a 1% SD in the MPI results in a 0.12% SD in $\bar{y}_t$ during the negative output gap period. The same deviation in the policy index

[25]The negative output gap periods are Q1 1991–Q2 1993, Q2 1997, Q4 1997–Q1 2007, Q2 2009, and Q1 2012–Q3 2014. The positive output gap periods are Q3 1993–Q1 1997, Q3 1997, Q2 2007–Q1 2009, and Q3 2009–Q4 2011.

results in a 0.23% deviation in $\bar{y}_t$ during the positive or neutral output gap period. This indicates a stronger reaction of the output gap to changes in policy variables during periods of a positive output gap, which is concurrent with the results of our MS estimations. The coefficients of the demand shock are also not significantly different over the two periods, with a coefficient of 0.012 and 0.010 for the positive and negative output gap periods, respectively. However, a 1% SD in the demand shocks leads to a 0.05% change in $\bar{y}_t$ in the negative gap period and a 0.24% change in the positive gap period. This confirms the relative importance of exports in the closing of the PRC's output gap. This also concurs with our findings in section V.C.

From the results of these simple robustness tests, it appears that the results and the findings from our Bai–Perron and MS estimations are fairly robust.

VII. Conclusion

In examining the link between monetary policy and the real economy in the PRC using different variations of the IS equation, this paper has made several interesting findings. The results of the traditional OLS model indicate that there is a significant and stable link between the lending interest rate set by the PBOC and aggregate demand in the PRC's economy. This is at odds with the majority of studies on the topic that suggest it is difficult to estimate a stable and robust aggregate demand equation for the PRC. It is important to note, however, that the size of the effect is small. This can be attributed to the underdevelopment of the banking system, market segmentation, the ineffectiveness of the credit channel, and the fact that the PBOC relies heavily on many different tools in the conduct of monetary policy. Given these findings, we then estimated an IS curve with an MPI comprising the tools used by the PBOC between 1991 and 2014. This index is a composite measure of the relevant variables observed to be at the disposal of the PBOC, both quantitative and qualitative, and therefore was expected to give a much better representation of the monetary policy stance of the PRC's central bank. The presence of structural breaks indicates that there is asymmetry between monetary policy action and output depending on the state of the economy and the time period.

A monetary policy index IS curve using a breakpoint model was estimated. The results confirmed the presence of a break in late 1994. The results of this model suggest that the monetary policy instruments of the PBOC have had less of an effect on the level of output since this breakpoint. While this seems counterintuitive, due to increased reforms in the finance sector, as well as measures that have promoted greater PBOC independence, the result is attributed to the adoption of the US dollar peg exchange rate regime in 1994.

Finally, an MS–IS curve using our MPI was estimated. This technique provided us with a different perspective on the monetary policy transmission channel as it allowed for switching between different regimes or states. This nonlinear

technique allows us to examine asymmetry in the monetary policy transmission channel. Testing for this type of asymmetry is important due to the underdeveloped nature of the PRC's financial system and the huge amount of reform and structural change that the economy has experienced. Our results suggest that there is a significant link between the monetary policy tools used by the PBOC and the real economy in State 2 of our model, when output is mostly operating at or above its potential level. This relationship breaks down when the economy switches to periods that are characterized by output that is mostly below potential. Finally, our MS model seems to suggest that demand shocks have a much greater effect in State 2 (mostly positive output gap) than in State 1 (mostly negative output gap). This points to the importance of exports in closing the gap between potential and actual output in the PRC.

The results of the paper seem to suggest that the PRC's exchange rate policy has restricted the effectiveness of the PBOC's monetary policy response. While there have been some significant developments in recent years, further liberalization of the exchange rate regime would facilitate greater monetary policy independence and effectiveness. If monetary policy is less effective, or even ineffective, when output is operating below potential, as our results suggest, then the PBOC will need to resort to alternative monetary policy tools to continue to achieve its goal of maintaining economic growth. This could be aided by further reform of the finance and banking sectors to help reduce output volatility and allow for greater symmetry in the transmission of monetary policy.

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APPENDIX: Summary Statistics

	OLS Estimations	Breakpoint Model		Markov Switching Model		Robustness Test	
	Q2 1991–Q3 2014	Period 1 (Q2 1991–Q4 1994)	Period 2 (Q1 1995–Q3 2014)	State 1	State 2	Positive Output Gap	Negative Output Gap
Mean of output gap	−1.0%	−1.5%	−0.8%	−1.4%	0.7%	1.1%	−2.1%
Standard deviation of output gap	2.1%	3.4%	1.6%	2.6%	1.5%	0.8%	1.5%
Mean of real interest rate	2.8%	—	—	—	—	—	—
Standard deviation of real interest rate	4.3%	—	—	—	—	—	—
Mean of Monetary Policy Index	−0.2%	0.5%	−0.3%	−0.3%	0.4%	−0.4%	−0.1%
Standard deviation Monetary Policy Index	1.5%	2.1%	1.3%	1.1%	2.0%	1.5%	1.4%
Mean of demand shock (exports)	12.5%	17.4%	11.6%	13.6%	9.4%	10.3%	13.8%
Standard deviation of demand shock (exports)	12.1%	10.9%	12.2%	10.4%	16.6%	15.2%	9.8%

OLS = ordinary least squares.
Source: Authors' calculations.

Dynamic Effects of Changes in the Exchange Rate System

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We propose a new dynamic transition analysis on the basis of a small open economy dynamic stochastic general equilibrium model. Our proposed analysis differs from existing static and conventional dynamic analyses in that shifts from a fixed exchange rate regime to a basket peg or a floating regime are explicitly explored. We apply quantitative analysis, using data from the People's Republic of China and Thailand, and find that both economies would be better off shifting from a dollar peg to a basket peg or a floating regime over the long run. Furthermore, the longer the transition period, the greater the benefits of shifting to a basket peg regime from a dollar peg regime owing to limited volatility in interest rates. Regarding sudden shifts to a desired regime, the welfare gains are larger under a shift to a basket peg if the exchange rate fluctuates significantly.

Keywords: basket peg, dynamic transition analysis, East Asia, exchange rate regime, transition path
JEL codes: F33, F41, F42

I. Introduction

We have witnessed many shifts in exchange rate regimes in emerging market economies over the last 3 decades. Economies such as Chile, Israel, and Poland have undergone gradual adjustments of their exchange rate toward a free-floating regime, while others—such as the Czech Republic, Jamaica, Lithuania, and Uruguay—have chosen to make rapid exchange rate adjustments.[1] Most economies in the Association of Southeast Asian Nations, the People's Republic of China (PRC), Japan, and the Republic of Korea (ASEAN+3) have experienced shifts from one regime to another in the period following the 1997/98 Asian financial crisis.

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[1] See Yoshino, Kaji, and Asonuma (2015c) for more details.

Some of these economies also implemented capital account measures during the postcrisis period.

The literature on exchange rate regimes has explored only static and conventional dynamic analyses. Static analysis focusing on the 1997/98 Asian financial crisis relies on losses over a short time horizon (e.g., 1 quarter). It then compares optimality among a dollar peg, a basket peg, and a floating regime, given free capital mobility. The regime under each option in the static analysis is restricted to one type of exchange rate regime.[2] In contrast, conventional dynamic analysis covers a longer time horizon (e.g., 10 years or an infinite time horizon). Similar to static analysis, exchange rate regimes are assumed to remain stable over the specified horizon and are compared with one another to determine the most desirable regime over the long run.[3]

Though both static and conventional dynamic analyses were quite appropriate in the aftermath of the 1997/98 Asian financial crisis, the scope to which monetary authorities can apply these analyses has become more limited over time. Among the critical drawbacks with these types of analysis is that they do not take into consideration shifts in one exchange rate regime to another or the costs associated with such shifts. Obviously, any shift to a different regime entails costs for the monetary authorities. Equally important, all of the exchange rate regimes included in static and dynamic analyses operate under free capital mobility rather than strict or weak capital controls.

These limitations raise an important question that has not yet been answered in the literature on exchange rate policy in East Asia: can we construct a new approach to theoretical analysis in the context of East Asian economies that have experienced shifts from one regime to another?

This paper proposes a new "dynamic transition analysis" on the basis of a small open economy dynamic stochastic general equilibrium (DSGE) model. Our proposed analysis differs from existing analysis in that shifts from a fixed exchange rate regime to a basket peg or a floating regime are explicitly explored. Moreover, during the shifts, we incorporate changes in capital account restrictions. In particular, we consider five policies: (1) maintaining a dollar peg (with strict capital controls), (2) a gradual shift from a dollar peg to a basket peg without capital controls (a gradual adjustment of both capital controls and basket weight), (3) a sudden shift from a dollar peg to a basket peg without capital controls (a sudden removal of capital controls and a sudden change in basket weight), (4) a sudden shift from a dollar peg to a floating regime (a sudden removal of capital controls and a sudden increase in flexibility in the exchange rate), and (5) a sudden shift from a dollar peg to a managed-floating regime (a sudden removal of capital controls and a sudden

[2]For East Asia, see Ito, Ogawa, and Sasaki (1998); Ogawa and Ito (2002); Yoshino, Kaji, and Suzuki (2004); and Yoshino, Kaji, and Asonuma (2004).

[3]For East Asia, see Yoshino, Kaji, and Suzuki (2002); and Shioji (2006a, 2006b).

increase in flexibility in the exchange rate with occasional interventions). For each transition policy, we obtain a theoretical expression for the cumulative loss.

On the basis of our dynamic transition analysis, we draw four conclusions. First, we find that maintaining a dollar peg is desirable only over the short run, which suggests that an economy will be better off shifting to either a basket peg or a floating regime over the long run. Second, given the choice between a gradual adjustment toward the target basket peg, policy (2), or a sudden shift to the target basket peg, policy (3), a longer transition period will deliver greater benefits to the economy than immediately implementing the desired regime.

Third, given the comparison between a sudden shift to a basket peg, policy (3), and a sudden shift to a floating regime, policy (4), the welfare gains to an economy would be higher under a shift to a basket peg if the exchange rate fluctuates significantly. The economy would be able not only to stabilize the negative impacts of exchange rate fluctuations on trade and capital inflows, but also allow the private sector to formulate exchange rate expectations by committing to a basket peg over the long run. Lastly, it is less beneficial to shift to a managed-floating regime than to a basket peg because intervening in the foreign exchange market leads to greater losses since the relevant authority lacks monetary policy autonomy. Our quantitative analysis using data from the PRC and Thailand supports these findings.[4] Our analysis can be applied to any small open economy that is considering a shift from a fixed-rate regime to a basket peg or floating regime.[5]

The rest of the paper is structured as follows. In section II, we provide an overview of the development of exchange rate regimes and capital account management in ASEAN+3 in the post-Asian financial crisis period. In section III, we explain the limitations of both static and conventional dynamic analyses with regard to exchange rate regimes. Section IV provides a DSGE model of a small open economy and analyzes how an economy reaches a state of stable equilibrium under each of the five policy regimes described above. In section V, we define in more detail these five exchange rate policies, which include four transition policies and a policy of maintaining a dollar peg. Section VI focuses on the optimal transition policy. Simulation exercises using data from the PRC and Thailand are provided in Section VII. Section VIII concludes.

A. Literature Review

Several previous studies explore desirable exchange rate regimes in East Asia in the static context. On the one hand, Ito, Ogawa, and Sasaki (1998) and Ogawa and Ito (2002) find that a basket peg is desirable in a general equilibrium model that

[4] Yoshino, Kaji, and Asonuma (2012) analyze a comparison between a basket peg and a floating regime by implementing specified instrument rules for the cases of Singapore and Thailand.

[5] Yoshino, Kaji, and Asonuma (2015b) explore the cases of Malaysia and Singapore, without changes in capital account management, following the PRC's transition to a desirable regime.

does not involve capital movements.[6] Similarly, Yoshino, Kaji, and Suzuki (2004); and Yoshino, Kaji, and Asonuma (2004) confirm the optimality of a basket peg in a general equilibrium model with capital movements across economies. On the other hand, Adams and Semblat (2004), Sussangkarn and Vichyanond (2007), and Kim and Lee (2008) emphasize the advantages of a floating regime by showing that exchange rate flexibility provides greater monetary policy independence, particularly with regard to inflation targeting. For an empirical analysis, McKibbin and Lee (2004) investigate which exchange rate East Asian economies should peg to by using economy-specific (asymmetric) shocks and regional (symmetric) shocks.

The other stream of literature discusses conventional dynamic analyses of exchange rate regimes in the region. In this analysis, monetary authorities are assumed to maintain the current exchange rate regime over the long run. Yoshino, Kaji, and Suzuki (2002) show that a basket peg achieves the least cumulative loss among three exchange rate regime options. Shioji (2006a, 2006b) confirms the superiority of a basket peg to a dollar peg in a dynamic model using two firm-level invoicing schemes: producer currency pricing and vehicle currency pricing. Yoshino, Kaji, and Asonuma (2012) contrast a basket peg regime with a floating regime using specified instrument rules.[7]

We have also reviewed studies on adjustments to capital account management in East Asian economies.[8] Ariyoshi et al. (2000), Kawai and Takagi (2004), and Meesok et al. (2001) discuss Malaysia's experience with outflow controls and conclude that these controls appear to have achieved their objective of securing monetary independence under a fixed exchange rate. On capital account restrictions in the PRC, Goldstein and Lardy (2006) stress the immediate removal of capital controls, while Cappiello and Ferrucci (2008) propose the progressive removal of controls in sequence with exchange rate reform.[9]

II. Exchange Rate Regimes and Capital Account Management in ASEAN+3

Table 1 summarizes transitions in de jure exchange rate regimes in ASEAN+3 in 1999–2008.[10] We observe two patterns of development in exchange rate regimes.

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[6] See also Kawai (2004), Ito and Park (2003), and Bird and Rajan (2002) for discussions on the desirability of a basket peg. For more details on the exchange rate regimes of Hong Kong, China, and Singapore, see Devereux (2003).

[7] Yoshino, Kaji, and Asonuma (2015a) explore whether actual policies that have been implemented by East Asian economies since the 1997/98 Asian financial crisis follow or deviate from theoretically desirable policies over the medium and long run.

[8] On adjustments to capital controls in other emerging market economies, see Ostry et al. (2011a, 2011b); Edwards and Rigobon (2009); and Forbes (2007). Baba and Kokenyne (2011) document capital account management measures in the Republic of Korea and Thailand during the 2000s.

[9] Bayoumi and Ohnsorge (2013) argue that capital account liberalization in the PRC may trigger net portfolio outflows as holders of large savings seek to diversify abroad. See also Ma and McCauley (2007) for more details on capital account liberalization and monetary policy in the PRC.

[10] According to the IMF (2009, 2011), de jure exchange rate arrangements are those which the authorities have officially announced. On the contrary, Ilzetzki, Reinhart, and Rogoff (unpublished) define alternative classifications

Table 1. **Transitions of De Jure Exchange Rate Regimes in ASEAN+3**

Economy	1999[a]	2002[a]	2005[a]	2008[a]
People's Republic of China	Conventional pegged arrangement	Conventional pegged arrangement	Conventional pegged arrangement	Stabilized arrangement
Indonesia	Independently floating	Managed floating with no preannounced path for the exchange rate	Managed floating with no predetermined path for the exchange rate	Floating
Japan	Independently floating	Independently floating	Independently floating	Free floating[b]
Republic of Korea	Independently floating	Independently floating	Independently floating	Free floating[b]
Malaysia	Conventional pegged arrangement	Conventional pegged arrangement	Managed floating with no predetermined path for the exchange rate	Floating[c]
Philippines	Independently floating	Independently floating	Independently floating	Floating
Singapore	Managed floating with no preannounced path for the exchange rate	Managed floating with no preannounced path for the exchange rate	Managed floating with no predetermined path for the exchange rate	Floating[d]
Thailand	Independently floating	Managed floating with no preannounced path for the exchange rate	Managed floating with no predetermined path for the exchange rate	Managed floating with no predetermined path for the exchange rate

ASEAN+3 = Association of Southeast Asian Nations plus the People's Republic of China, Japan, and the Republic of Korea.

Notes:

[a]See IMF (2000, 2003, 2006) for categories of exchange rate arrangements in 1999, 2002, and 2005, respectively. See IMF (2009) for categories of exchange rate arrangements in 2008. In 2003, "the managed floating with no preannounced path for the exchange rate" was changed to the managed floating with no predetermined path for exchange rate.

[b]According to IMF (2009), a floating exchange rate is largely market determined, without an ascertainable or predictable path for the rate.

[c]The Malaysian ringgit is managed with reference to a currency basket. The composition of the basket is not disclosed.

[d]The Singapore dollar is allowed to fluctuate within a targeted policy band and is managed against a basket of currencies of the economy's major trading partners and competitors.

Sources: International Monetary Fund (IMF). 2000. *Annual Report on Exchange Rate Arrangements and Exchange Restrictions*. Washington, DC; IMF. 2003. *Annual Report on Exchange Rate Arrangements and Exchange Restrictions*. Washington, DC; IMF. 2006. *Annual Report on Exchange Rate Arrangements and Exchange Restrictions*. Washington, DC; IMF. 2009. *Annual Report on Exchange Rate Arrangements and Exchange Restrictions*. Washington, DC.

First, most economies in ASEAN+3 have experienced a shift from one regime to another in the post-Asian financial crisis period, or at least a small degree of change.

of exchange rate arrangements based on market-determined exchange rates. Their de facto classifications enable us to assess the underlying monetary policy and the ability of an economy to adjust to external imbalances. Appendix 1 reports the recent transitions of de facto regimes.

Some economies, such as the PRC and Malaysia, have increased the flexibility of their exchange rate regimes.[11] Second, other economies, such as Japan and the Republic of Korea, have maintained their (free-floating) exchange rate regime unchanged over the period.

Table 2 reports the primary changes in capital account management measures in the Republic of Korea, Malaysia, and Thailand in 1998–2010.[12] Faced with spillover effects from the 1997/98 Asian financial crisis, Malaysian authorities initially eliminated offshore ringgit activities and limited portfolio capital outflows. Later, the authorities reversed their strategy, gradually relaxing restrictions on portfolio outflows and offshore transactions. The Republic of Korea moved toward capital outflow liberalization only after the economy had recovered from the crisis. Limits on outward investment were relaxed further in the mid-2000s, leading to the elimination of most controls by 2007. In Thailand, authorities restricted baht deposits for nonresidents. In 2006, they introduced an unremunerated reserve requirement of 30% on capital inflows.

III. Limitation of Existing Static and Conventional Dynamic Analyses

Existing static and conventional dynamic analyses are appropriate for comparing the status quo exchange rate regime with a more desirable one (e.g., a dollar peg regime that most East Asian economies had adopted prior to the onset of the 1997/98 Asian financial crisis).

However, the scope to which monetary authorities can apply these static and conventional dynamic analyses has become more limited. Specifically, these types of analyses have four drawbacks when applied to East Asian economies in the post-Asian financial crisis period.

First, and most importantly, these analyses have taken into consideration neither shifts in exchange rate regimes nor the costs associated with shifts. As discussed in section II, the majority of East Asian economies announced their departure from a de facto dollar peg at the onset of the 1997/98 Asian financial crisis and then experienced several changes to their exchange rate regime in the aftermath of the crisis. Obviously, any shift to a different regime entails costs for the relevant monetary authority.

Second, and related to the first point, these analyses do not reflect where East Asian economies currently stand (status quo regime). They rely on the assumption that these economies have implemented a regime that is more desirable than the

[11] Ma and McCauley (2011) find that in the 2-year period from mid-2006 to mid-2008 the Chinese renminbi strengthened gradually against trading partner currencies within a narrow band.

[12] Yoshino, Kaji, and Ibuka (2003) analyze the effectiveness of capital controls and fixed exchange rates in the case of Malaysia.

Table 2. **Capital Account Management Measures, 1998–2010**

Economy	Period	Major Policy Measures
Republic of Korea	2001–2008	Outflow liberalization • Elimination of limits on deposits • Relaxation of limits on lending to nonresidents
Malaysia	1998–2001	Outflows controls • Controls on transfers of funds from MYR-denominated accounts for nonresidents • Removal of the partial and complete exit levies on repatriation of principal
	1998–2001	Ringgit transactions • Limit offshore ringgit transactions through restrictions on transfer of funds between MYR-denominated accounts of nonresidents
	2001–2008	Ringgit transactions • Abolish restriction on ringgit lending to nonresident-controlled companies onshore • Liberalization of restrictions on ringgit borrowing from and lending to nonresidents
	1998–2010	Flexibilities on outflows • Gradual liberalization of restrictions on investments in foreign currency assets • Liberalization to allow settlement of international trade of goods and services with nonresidents in ringgit
Thailand	2006–2008	Unremunerated reserve requirement (URR) • Introduction of a 1-year URR for capital inflows • Elimination of the URR
	2003–2008	Inflow controls • Limits on short-term borrowing from nonresidents without underlying and on investments in government debt securities
	2002–2008	Outflow liberalization • Relaxation of limits on residents' investments in foreign affiliates and lending abroad

MYR = Malaysian ringgit.

Sources: Ariyoshi, A., K. Habermeier, B. Laurens, I. Ötker–Robe, J. I. Canales–Kriljenko, and A. Kirilenko. 2000. Capital Controls: Country Experiences with Their Use and Liberalization. IMF Occasional Paper No. 190. Washington, DC: International Monetary Fund (IMF); Baba, C., and A. Kokenyne. 2011. Effectiveness of Capital Controls in Selected Emerging Markets in the 2000s. IMF Working Paper WP/11/281. Washington, DC: IMF; IMF. 2014. *Annual Report on Exchange Rate Arrangements and Exchange Restrictions*. Washington, DC; Kawai, M., and S. Takagi. 2004. Rethinking Capital Controls: The Malaysian Experience. In S. Chirathivat, E. M. Claassen, and J. Schroeder, eds. *East Asia's Monetary Future: Integration in the Global Economy*. Cheltenham, UK and Northampton, MA: Edward Elgar; Meesok, K., I. H. Lee, O. Liu, Y. Khatri, N. Tamirisa, M. Moor, and M. H. Krysl. 2001. Malaysia: From Crisis to Recovery. IMF Occasional Paper No. 207. Washington, DC: IMF.

previous regime. However, in reality, the current exchange rate regime is not necessarily the most desirable regime over the long run.

Third, all exchange rate regimes in the static and dynamic analyses operate under free capital mobility rather than strict or weak capital controls. However, these models are in contrast with recent developments in capital account restrictions in East Asian economies as reported in section II. For example, Malaysia and Thailand implemented capital account restrictions immediately at the onset of the 1997/98 Asian financial crisis and only relaxed these controls gradually in the aftermath

of the crisis. Changes in capital account measures, particularly the removal of capital controls, need to be considered in the context of exchange rate regimes since exchange rates and interest rates are significantly influenced by any change in capital account measures.

Lastly, not only have shifts in exchange rate regimes not been explored yet, but also the analyses have not focused on how adjustments should be implemented. Monetary authorities must choose between gradual and rapid adjustments.[13] On the one hand, the entire transition process of increasing flexibility in the exchange rate regime includes several intermediate regimes in which exchange rates are allowed to fluctuate more than under the previous regime. On the other hand, the monetary authorities could suddenly abandon a fixed regime and adopt a new market-determined exchange rate regime.

These drawbacks in the static and conventional dynamic analyses call for a need to develop an alternative dynamic analysis that suits East Asian economies, particularly in the post-Asian financial crisis period.

IV. Macroeconomic Models and Exchange Rate Regimes

A. Dynamic Model of a Small Open Economy

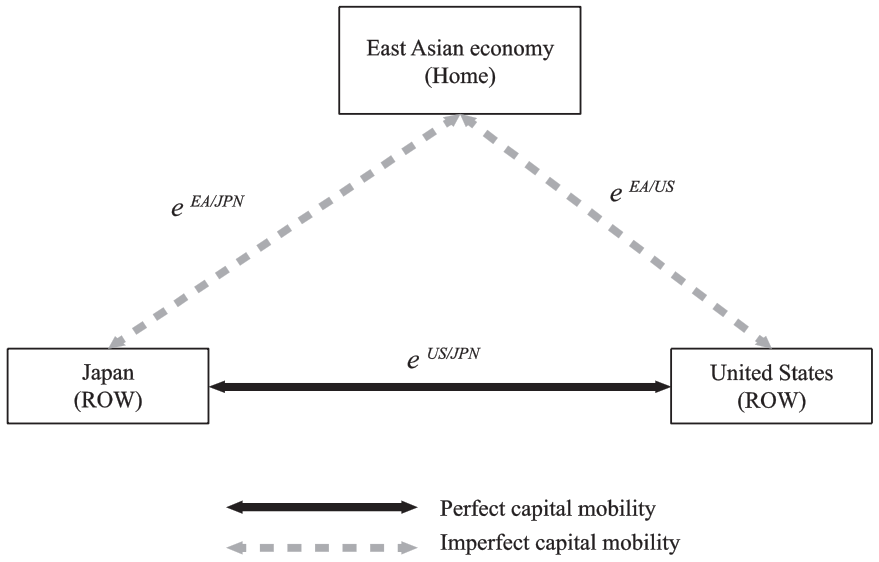
This section provides a DSGE model for a small open economy. Our model closely follows Dornbusch (1976) and Yoshino, Kaji, and Suzuki (2002) as we analyze in the dynamic context. Although we do not derive equilibrium conditions directly from the optimal behavior of households and firms, our equilibrium conditions are the same as those in Yoshino, Kaji, and Asonuma (2012, 2015b), which are built on microfoundations. The main rationale of our modeling approach is rooted in it being a better fit with the data for East Asia: when we obtain estimated coefficients from regressions using macroeconomic data, our model is well specified and is a good fit with available data for East Asian economies. There are three economies in our model: the East Asian economy, Japan, and the United States (US) (Figure 1). We assume the East Asian economy to be the home economy, and Japan and the US to be the rest of the world. The yen–dollar exchange rate is exogenous to the home economy. Detailed description of variables in the model is reported in Table 3.

Domestic and foreign assets are assumed to be imperfect substitutes for domestic investors, while Japanese and US assets are perfect substitutes. An interest parity condition is shown as

$$i_{t+1} - i_t = -\lambda\left[i_t - \left\{i_t^{US} + e_{t+1}^{EA/US} - e_t^{EA/US} - \sigma\left(e_t^{EA/US}\right)\right\}\right] \tag{1}$$

[13] Yoshino, Kaji, and Asonuma (2015c) describe examples of economies that have benefited from each of these types of adjustments.

Figure 1. **Small Open Economy and the Rest of the World**



EA = East Asian currency, JPN = Japan, ROW = rest of the world, US = United States.
Source: Authors' compilation.

Table 3. **Description of Variables**

Variable	Description	Variable	Description
m	Stock of money supply	α	Total productvitiy of home economy
p	Price level in home economy	p^{US}	Price level in the US
p^e	Expected domestic price level	p^{JPN}	Price level in Japan
i	Home economy interest rate	i^{US}	US interest rate
y	Home gross domestic product	$\bar{y}$	Potential gross domestic product
$e^{EA/US}$	East Asian currency–US dollar exchange rate	$e^{EA/JPN}$	East Asian currency–yen exchange rate
$e^{US/JPN}$	US dollar–yen exchange rate	υ	Basket weight of the US dollar rate in a currency basket
$\Delta e^{EA/US}$	US dollar exchange rate risk	$\Delta e^{EA/JPN}$	Yen exchange rate risk

US = United States.
Note: All variables, except interest rates, are defined in natural logs.
Source: Authors' compilation.

where λ denotes the adjustment speed of the domestic interest rate, which also captures the degree of capital controls. If λ is close to 0, it implies that the domestic interest rate does not respond to an interest rate differential. This means that the domestic interest rate is exogenous and totally independent. We regard this as a case of strict capital controls. If λ is between 0 and 1, the domestic interest rate responds only partially to a change in foreign interest rate. On the contrary, if λ approaches 1, it implies that the domestic interest rate responds completely to a change in the foreign interest rate. We consider this a case of no capital controls. Moreover, in the case $0 < \lambda \leq 1$, if domestic interest rate is higher than the expected

return on foreign assets (the foreign interest rate and expected depreciation rate), the economy receives capital inflows. Otherwise (if the domestic interest rate is lower than expected return on foreign assets), the economy experiences capital outflows. Lastly, $\sigma(e_t^{EA/US})$ denotes a risk premium that depends on the US dollar exchange rate. If $\lambda = 1$, Equation (1) can be rewritten as

$$i_{t+1} = i_t^{US} + e_{t+1}^{EA/US} - e_t^{EA/US} - \sigma\left(e_t^{EA/US}\right) \tag{1'}$$

The equilibrium condition for the money market is

$$m_t - p_t = -\varepsilon i_{t+1} + \phi(y_t - \bar{y}) \tag{2}$$

The demand for goods depends on the real US dollar and yen rates, exchange rate expectations, real interest rate, and exchange rate risks. It is written as

$$\begin{aligned} y_t - \bar{y} = {} & \delta\left(e_t^{EA/US} + p^{US} - p_t\right) + \delta' e_{t+1}^{\frac{EA}{US},e} + \theta\left(e_t^{EA/JPN} + p^{JPN} - p_t\right) + \theta' e_{t+1}^{\frac{EA}{JPN},e} \\ & - \rho\left\{i_{t+1} - \left(p_{t+1}^e - p_t^e\right)\right\} - \tau\,\Delta e_t^{EA/US} - \varsigma\,\Delta e_t^{EA/JPN} \end{aligned} \tag{3}$$

where the term $(p_{t+1}^e - p_t^e)$ shows the expected inflation rate. The last two terms correspond to exchange rate risks.

Since one of the three exchange rates is not independent, the yen rate can be expressed as

$$e_t^{EA/JPN} = e_t^{EA/US} + e_t^{US/JPN} \tag{4}$$

The inflation rate depends on total productivity, excess demand for goods, the real US dollar rate, the real yen rate, exchange rate expectations, and the expected rate of inflation. It is shown as

$$\begin{aligned} p_{t+1} - p_t = {} & -\alpha_t + \psi(y_t - \bar{y}) + \eta\left(e_t^{EA/US} + p^{US} - p_t\right) + \eta' e_t^{EA/US,e} \\ & + \mu\left(e_t^{EA/JPN} + p^{JPN} - p_t\right) + \mu' e_t^{EA/JPN,e} + \left(p_{t+1}^e - p_t^e\right) \\ & + \chi\,\Delta e_t^{EA/US} + \xi\,\Delta e_t^{EA/JPN} \end{aligned} \tag{5}$$

where the first term on the right-hand side shows the total productivity of the home economy and the last two terms denote the US dollar and yen exchange rate risks. We assume aggregate production depends on total productivity, imported materials from Japan and the US, and the expected inflation rate. The home economy is assumed to import materials from Japan and the US, and to export final goods to Japan and the US. Both aggregate demand and aggregate supply also depend on exchange rate expectations, as exporting and importing firms are concerned with significant

deviations from the current exchange rate in the future. Among the variables, α_t, $\bar{y}$, p^{US}, p^{JPN}, $e_t^{US/JPN}$ are common exogenous variables under any exchange rate regime. We assume that all exogenous variables except $e_t^{US/JPN}$, p_{t+1}^e, p_t^e, $e_t^{EA/US,e}$, $e_t^{EA/JPN,e}$, $\Delta e_t^{EA/US}$, and $\Delta e_t^{EA/JPN}$ are constant (= 0) in the analysis below. All of the coefficients above are positive.

B. Exchange Rate Regimes

Next, we derive the long-run equilibrium together with equilibrium values at period t for the following exchange rate regimes:

(A) dollar peg with strict capital controls,

(B) basket peg with weak capital controls,

(C) basket peg without capital controls,

(D) floating regime without capital controls, and

(E) dollar peg without capital controls.

1. Dollar Peg with Strict Capital Controls (A)

Under a dollar peg, the US dollar rate becomes exogenous ($e_t^{EA/US} = 0$). Moreover, the money supply (m_t) becomes endogenous, implying that the money supply is adjusted whenever the monetary authority intervenes into the foreign exchange market by adjusting its holdings of foreign and domestic assets. Both the size and frequency of interventions are fully reflected through changes in the money supply. Since the monetary authority restricts domestic residents' holdings of foreign assets, Equation (1) does not exist. The domestic interest rate (i_{t+1}) is a policy instrument (exogenous). As the East Asian currency–US dollar rate is fixed, Equation (4) provides:

$$e_t^{EA/JPN} = e_t^{US/JPN} \tag{4'}$$

Endogenous variables in this case are m_t, y_t, and p_t. Solving Equations (2), (3), (4′), and (5) for the price level and money supply, we obtain semireduced form equations:

$$\begin{aligned} p_{t+1} - p_t = &-\alpha_t - [\psi(\delta+\theta) + (\eta+\mu)]\, p_t + \psi\theta e_t^{US/JPN} + \psi(\theta'+\mu')e_{t+1}^{US/JPN,e} \\ &+ (1+\psi\rho)\left(p_{t+1}^e - p_t^e\right) + (\xi - \psi\varsigma)\,\Delta e_t^{EA/JPN} - \psi\rho i_{t+1} \end{aligned} \tag{6}$$

$$m_t = [1 - \phi(\delta + \theta) + (\eta + \mu)]\, p_t + \phi\theta e_t^{US/JPN} + \phi\theta' e_{t+1}^{US/JPN,e} + \phi\rho\left(p_{t+1}^e - p_t^e\right) - \phi\varsigma\,\Delta e_t^{EA/JPN} - (\varepsilon + \phi\rho)\rho i_{t+1} \quad (7)$$

The long-run equilibrium values for the price level and money supply under a dollar peg are[14]

$$\bar{p}_A = \frac{1}{E_1}[\{\psi(\theta + \theta') + \mu'\}\bar{e}^{US/JPN} - \psi\rho\bar{i} - \bar{\alpha}] \quad (8)$$

$$\bar{m}_A = \left[\frac{E_1'}{E_1}\{\psi(\theta+\theta')+\mu'\}+\phi(\theta+\theta')\right]\bar{e}^{US/JPN} - \frac{E_1'}{E_1}\bar{\alpha} - \left[\frac{E_1'}{E_1}\psi\rho + (\varepsilon+\phi\rho)\right]\bar{i}_A \quad (9)$$

where $E_1 = \psi(\delta + \theta) + (\eta + \mu)$ and $E_1' = 1 - \phi(\delta + \theta) + (\eta + \mu)$.

$\hat{X}_t = X_t - \bar{X}$ expresses the deviation from the long-run equilibrium value. We assume that the US dollar–yen rate moves from its initial equilibrium value (= 0) to $\hat{e}_t^{US/JPN}$ at time t and remains at the new equilibrium after time $t + 1$ (= $\hat{e}_t^{US/JPN}$). As the price level is sticky over the short run, $p_0 = 0$ at time 0. We assume the initial equilibrium values $\bar{p}_0 = \bar{e}_0 = 0$. The new equilibrium value after the US dollar–yen rate change is

$$\bar{p}_A = \frac{1}{E_1}\left[\begin{array}{l}\psi\theta\hat{e}_t^{US/JPN} + \psi(\theta' + \mu')\,\hat{e}_{t+1}^{US/JPN,e} + (1 + \psi\rho)\left(\hat{p}_{t+1}^e - \hat{p}_t^e\right) \\ \quad + (\xi - \psi\varsigma)\,\Delta\hat{e}_t^{EA/JPN} - \psi\rho\bar{i}_A\end{array}\right] \quad (10)$$

where we assume that total productivity remains unchanged by exchange rate shocks (i.e., $\hat{\alpha}_t = 0$). We solve for the rational expectation and obtain expressions for $y_t - \bar{y}_A'$ and $p_t - \bar{p}_A'$ such that[15]

$$y_t - \bar{y}_A' = A_1(t)\hat{e}_t^{US/JPN} + A_2(t)\Delta\hat{e}_t^{EA/JPN} + A_3(t)i_{t+1} \quad (11)$$

$$p_t - \bar{p}_A' = A_1^p(t)\hat{e}_t^{US/JPN} + A_2^p(t)\Delta\hat{e}_t^{EA/JPN} + A_3^p(t)i_{t+1} \quad (11a)$$

A major cost of a dollar peg under strict capital controls is that long-run output might be negatively influenced due to limited capital flows. In this regard, we express the deviation of output and the price level from the new long-run equilibrium value under a basket peg without capital controls (C) ($\bar{\bar{y}}_A' = \bar{y}_C'$) as

[14] We assume that $p_{t+1}^e = p_t^e$ and $\Delta e^{EA/JPN} = 0$ at the long-run equilibrium.

[15] Expressions $A_1(t)$, $A_2(t)$, $A_3(t)$, $A_1^p(t)$, $A_2^p(t)$, $A_3^p(t)$ are shown in Appendix 2.A.

$$y_t - \bar{\bar{y}}'_A = (y_t - \bar{y}'_A) + (\bar{y}'_A - \bar{\bar{y}}'_A)$$
$$= \begin{bmatrix} \{A_1(t) + A'_1(t)\}\, \hat{e}_t^{US/JPN} + A_2(t)\Delta\hat{e}_t^{EA/JPN} \\ + A'_2(t)\Delta\hat{e}_t^{EA/JPN} + A_3(t) i_{t+1} \end{bmatrix} \tag{11′}$$

$$p_t - \bar{\bar{p}}'_A = (p_t - \bar{p}'_A) + (\bar{p}'_A - \bar{\bar{p}}'_A)$$
$$= \begin{bmatrix} \{A_1^p(t) + A_1'^p(t)\}\, e_t^{US/JPN} + A_2^p(t)\Delta\hat{e}_t^{EA/JPN} \\ + A_2'^p(t)\Delta\hat{e}_t^{EA/JPN} + A_3^p(t) i_{t+1} \end{bmatrix} \tag{11′a}$$

Note that $\bar{\bar{y}}'_A \equiv \bar{\bar{y}}'_C$ and $\bar{\bar{p}}'_A \equiv \bar{\bar{p}}'_C$. A clear shortcoming of a dollar peg with capital controls is that capital inflows are restricted, which leads to a lower long-run equilibrium value compared with that under a basket peg without capital controls.

2. Basket Peg with Weak Capital Controls (B)

As a basket peg is an exceptional case of a fixed regime, endogenous variables are the same as those under a dollar peg. In this case, the monetary authority adjusts the money supply by intervening in the foreign exchange market in order to maintain the value of the basket at a constant level. The impacts of foreign exchange market intervention have been captured in the model as well. The basket is a weighted average of the US dollar rate and yen rate, which is shown as

$$\upsilon e_t^{EA/US} + (1-\upsilon)\, e_t^{EA/JPN} = \Gamma \tag{12}$$

where Γ is the value of the basket. With Equations (4) and (12), we have

$$e_t^{EA/US} = -(1-\upsilon)\, e_t^{US/JPN}, \quad e_t^{EA/JPN} = \upsilon e_t^{US/JPN} \tag{12a}$$

Solving Equations (1), (3), (5), and (12a) for the price level and interest rate, the following semireduced form equations are obtained:

$$p_{t+1} - p_t = -\alpha_t + E_1 p_t + \begin{bmatrix} \psi\{\theta\upsilon - \delta(1-\upsilon)\} \\ + \mu\upsilon - \eta(1-\upsilon) \end{bmatrix} e_t^{US/JPN} - \psi\rho i_{t+1}$$
$$+ (1+\psi\rho)\left(p_{t+1}^e - p_t^e\right) + \begin{bmatrix} \psi\left\{\theta'\upsilon - \delta'(1-\upsilon)\right\} \\ + \mu'\upsilon - \eta'(1-\upsilon) \end{bmatrix} e_t^{US/JPN,e}$$
$$+ (\chi - \psi\tau)\,\Delta e_t^{EA/US} + (\xi - \psi\varsigma)\,\Delta e_t^{EA/JPN} \tag{13}$$

$$i_{t+1} - i_t = -\lambda i_t - \lambda(1-\upsilon)\, e_{t+1}^{US/JPN,e} + \lambda(1+\sigma)(1-\upsilon)\, e_t^{US/JPN} \tag{14}$$

As in the previous case, we assume the same exogenous US dollar–yen rate change. The new equilibrium value after the US dollar–yen rate change is

$$\bar{p}'_B = \frac{1}{E_1}\left\{\begin{bmatrix}\psi\{\theta\upsilon - (\delta+\rho+\rho\sigma)(1-\upsilon)\}\\ +\mu\upsilon - \eta(1-\upsilon)\end{bmatrix}\hat{e}_t^{US/JPN} + (\chi - \psi\tau)\Delta\hat{e}_t^{EA/US}\right.$$
$$+(\xi-\psi\varsigma)\Delta\hat{e}_t^{EA/JPN} - \psi\rho\bar{i}'_B + (1+\psi\rho)\left(\hat{p}^e_{t+1} - \hat{p}^e_t\right)$$
$$\left.+\begin{bmatrix}\psi\left\{\theta'\upsilon + (1-\upsilon)(\rho-\delta')\right\}\\ +\mu'\upsilon - \eta'(1-\upsilon)\end{bmatrix}\hat{e}_t^{US/JPN,e}\right\} \tag{15}$$

$$\bar{i}'_B = (1-\upsilon)\left[(1+\sigma)\hat{e}_t^{US/JPN} - \hat{e}_{t+1}^{US/JPN,e}\right] \tag{16}$$

We solve for the rational expectation and obtain expressions for $y_t - \bar{y}'_B$, $p_t - \bar{p}'_B$, and $i_t - \bar{i}'_B$[16]

$$y_t - \bar{y}'_B = B_1(t)\upsilon\hat{e}_t^{US/JPN} + B_2(t)\hat{e}_t^{US/JPN} + B_3(t)\hat{z}_t \tag{17}$$

$$p_t - \bar{p}'_B = B_1^p(t)\upsilon\hat{e}_t^{US/JPN} + B_2^p(t)\hat{e}_t^{US/JPN} + B_3^p(t)\hat{z}_t \tag{17a}$$

$$i_t - \bar{i}'_B = -(1-\upsilon)[(1+\sigma)(1-b_4)](1-\lambda)^t\hat{e}_t^{US/JPN} \tag{17b}$$

where $B_3(t)\hat{z}_t$ and $B_3^p(t)\hat{z}_t$ comprise both $\Delta\hat{e}_t^{EA/US}$ and $\Delta\hat{e}_t^{EA/JPN}$.

3. Basket Peg without Capital Controls (C)

Similar to the case of a basket peg with weak capital controls, we have Equation (12a). Since we assume no capital controls, we use Equation (1′) with $\lambda = 1$. Solving Equations (2), (3), (5), and (12a) for the price level and money supply, we have the same semireduced form as in Equation (13) and the following equation ($\lambda = 1$):

$$i_{t+1} = -(1-\upsilon)e_{t+1}^{US/JPN,e} + (1+\sigma)(1-\upsilon)e_t^{US/JPN} \tag{14′}$$

As in previous cases, we assume the same exogenous US dollar–yen rate change. The new equilibrium value after the US dollar–yen rate change is $\bar{y}'_C = \bar{y}'_B$ and $\bar{p}'_C = \bar{p}'_B$. We solve for the rational expectation and obtain expressions for $y_t - \bar{y}'_C$ and $p_t - \bar{p}'_C$:[17]

[16] We show how to solve for the rational expectation and derive Equations (17), (17a), and (17b), and expressions $B_1(t)$, $B_2(t)$, $B_3(t)$, $B_1^p(t)$, $B_2^p(t)$, and $B_3^p(t)$ in Appendix 2.B.

[17] We show how to solve for the rational expectation and derive Equations (18) and (18a), and expressions $C_1(t)$, $C_2(t)$, $C_3(t)$, $C_1^p(t)$, $C_2^p(t)$, and $C_3^p(t)$ in Appendix 2.C.

$$y_t - \bar{y}'_C = C_1(t)\upsilon\hat{e}_t^{US/JPN} + C_2(t)\hat{e}_t^{US/JPN} + C_3(t)\hat{z}_t \tag{18}$$

$$p_t - \bar{p}'_C = C_1^p(t)\upsilon\hat{e}_t^{US/JPN} + C_2^p(t)\hat{e}_t^{US/JPN} + C_3^p(t)\hat{z}_t \tag{18a}$$

4. Floating Regime wtihout Capital Controls (D)

Under a floating regime, we assume that the monetary authority chooses the desirable level for the money supply.[18] Therefore, the money supply (m_t) becomes exogenous and the interest rate becomes endogenous. Solving Equations (1′), (3), and (5), we obtain the following two equations:

$$e_t^{EA/US} = \frac{1}{E_2}\begin{bmatrix} -m_t - (\varepsilon + \phi(\delta+\theta))\, p_t + \phi\theta e_t^{EA/JPN} + \phi\rho\left(p_{t+1}^e - p_t^e\right) \\ + \phi\theta' e_{t+1}^{EA/JPN,e} + \{\varepsilon + \phi\rho + \phi(\delta' + \theta')\} e_{t+1}^{EA/US,e} \\ - \phi\tau\Delta\hat{e}_t^{EA/US} - \phi\varsigma\Delta\hat{e}_t^{EA/JPN} \end{bmatrix} \tag{19}$$

$$\begin{aligned} p_{t+1} - p_t = {} & -\alpha_t - E_3 p_t + E_4 m_t + E_5 e_t^{US/JPN} + E_6\left(p_{t+1}^e - p_t^e\right) + E_7 e_{t+1}^{EA/US,e} \\ & + E_8 e_{t+1}^{EA/JPN,e} + E_9\Delta\hat{e}_t^{EA/US} + E_{10}\Delta\hat{e}_t^{EA/JPN} \end{aligned} \tag{20}$$

where $E_2 = (1+\sigma)(\varepsilon + \phi\rho) - \phi(\delta+\theta)$.

Long-run equilibrium values can be obtained from the equations below:

$$\bar{e}_D^{EA/US} = -\frac{1}{f_4}\bar{m} - \frac{\varepsilon - \phi(\delta+\theta)}{f_4}\bar{p}_D \tag{21}$$

$$\bar{p}_D = \frac{f_6}{f_5}\bar{m} + \frac{f_7}{f_5}\bar{e}^{EA/JPN} - \frac{1}{f_5}\bar{\alpha} \tag{22}$$

where $f_4 = \sigma(\varepsilon + \phi\rho) - 2\phi(\delta+\theta)$.

As in previous cases, we assume the same exogenous US dollar–yen rate shock. The new equilibrium values after the shock are

$$\begin{aligned} \bar{p}'_D = {} & \frac{f_3 + \psi\rho f_1}{E(\varepsilon+\phi\rho)}\hat{m}_t + \frac{\phi\theta f_3 + \psi\theta\varepsilon f_1}{E(\varepsilon+\phi\rho)}\hat{e}_t^{EA/JPN} + g_1\left(\hat{p}_{t+1}^e - \hat{p}_t^e\right) \\ & + g_2\Delta\hat{e}_t^{EA/US} + g_3\Delta\hat{e}_t^{EA/JPN} \end{aligned} \tag{23}$$

$$\begin{aligned} \bar{e}'^{EA/US}_D = {} & -\frac{f_4 + \psi\rho f_2}{E(\varepsilon+\phi\rho)}\hat{m}_t + \frac{\phi\theta f_3 + \psi\theta\varepsilon f_1}{E(\varepsilon+\phi\rho)}\hat{e}_t^{EA/JPN} + g_1'\left(\hat{p}_{t+1}^e - \hat{p}_t^e\right) \\ & + g_2'\Delta\hat{e}_t^{EA/US} + g_3'\Delta\hat{e}_t^{EA/JPN} \end{aligned} \tag{24}$$

[18] An alternative is to assume that the monetary authority sets an optimal interest rate under a floating regime. In this case, the interest rate becomes exogenous and the money supply becomes endogenous. Our theoretical and quantitative results remain unchanged.

Solving for the rational expectation yields expressions for $y_t - \bar{y}'_D$ and $p_t - \bar{p}'_D$:[19]

$$y_t - \bar{y}'_D = D_1(t)\hat{e}_t^{US/JPN} + D_2(t)\hat{z}_t + D_3(t)m_t \tag{25}$$

$$p_t - \bar{p}'_D = D_1^p(t)\hat{e}_t^{US/JPN} + D_2^p(t)\hat{z}_t + D_3^p(t)m_t \tag{25a}$$

5. Dollar Peg without Capital Controls (E)

As with a dollar peg with strict capital controls, the East Asian currency–US dollar rate ($e_t^{EA/US}$) is totally exogenous ($e_t^{EA/US} = 0$) and the money supply is endogenous. Without capital controls, we have Equation (1′) and the domestic interest rate (i_{t+1}) is fixed at the level of the US interest rate (endogenous) (i.e., $i_{t+1} = i_t^{US}$). This drives high interest rate volatility due to changes in the US interest rate and results in more volatile output and price levels.

The long-run equilibrium values for the price level and the money supply under this regime are the same as in Equations (8) and (9): $\bar{y}_E = \bar{y}_A$ and $\bar{p}_E = \bar{p}_D$, respectively. As in previous cases, we assume the same exogenous US dollar–yen rate shock. New equilibrium values after the shock are the same under a US dollar peg with capital controls: $\bar{p}'_E = \bar{p}'_A$.

Solving for the rational expectation yields expressions for $y_t - \bar{y}'_E$ and $p_t - \bar{p}'_E$:

$$y_t - \bar{y}'_E = A_1(t)\hat{e}_t^{EA/JPN} + A_2(t)\Delta\hat{e}_t^{EA/JPN} \tag{26}$$

$$p_t - \bar{p}'_E = A_1^p(t)\hat{e}_t^{EA/JPN} + A_2^p(t)\Delta\hat{e}_t^{EA/JPN} \tag{26a}$$

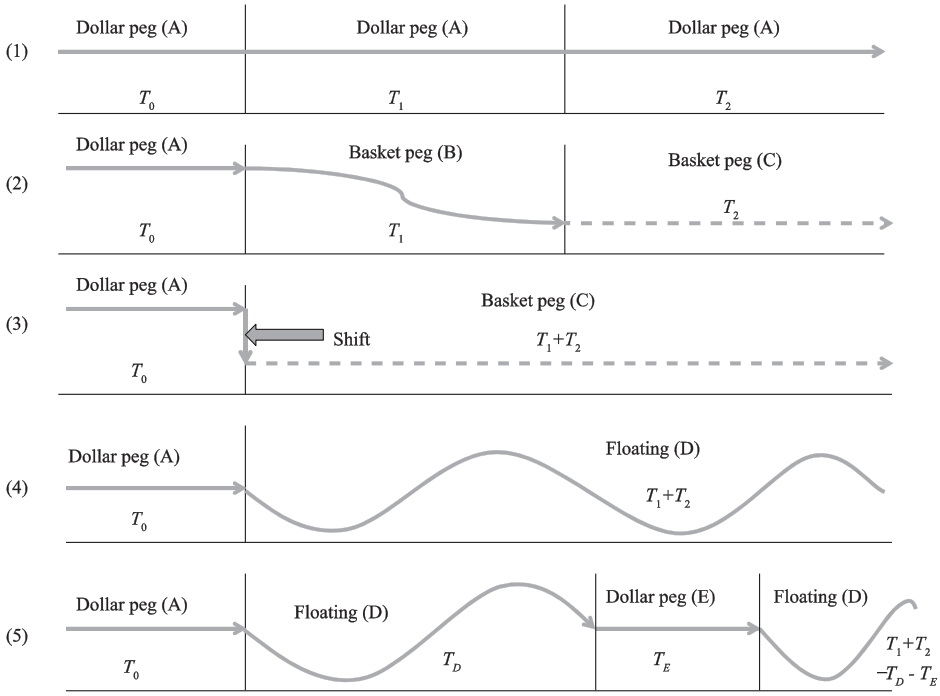
V. Transition Paths to Other Exchange Rate Regimes

In this section, we define four transition policies and a policy of maintaining the current regime. Yoshino, Kaji, and Suzuki (2004) find that when evaluated with a one-period loss, it would be desirable for a small open economy like Thailand to adopt a basket peg or a floating regime rather than a dollar peg. In the current context, this implies that the desirable regime over the long run is either a basket peg without capital controls or a floating regime without capital controls.[20] We consider four transition paths to the preferred regime, as well as maintaining the status quo

[19] We show how to solve for the rational expectation and derive Equations (25) and (25a) and expressions $D_1(t)$, $D_2(t)$, $D_3(t)$, $D_1^p(t)$, $D_2^p(t)$, $D_3^p(t)$ in Appendix 2.D. We show the saddle path stability under a floating regime in Appendix 3.

[20] Yoshino, Kaji, and Asonuma (2004) confirm that this is also the case for two small open economies that are interdependent.

Figure 2. **Transition Policies toward the Desired Regime**



Notes:
(A) dollar peg with strict capital controls
(B) basket peg with weak capital controls
(C) basket peg without capital controls
(D) floating regime without capital controls
(E) dollar peg without capital controls
Source: Authors' compilation.

(e.g., dollar peg with capital controls), using the (A)–(E) categorization of each exchange rate policy described in section IV (Figure 2):

(1) maintaining a dollar peg (with strict capital controls): (A),

(2) gradual shift from a dollar peg to a basket peg without capital controls (gradual adjustments of both capital controls and basket weights): (A) => (B) => (C),

(3) sudden shift from a dollar peg to a basket peg without capital controls (sudden removal of capital controls and sudden shift of basket weights): (A) => (C) => (C),

(4) sudden shift from a dollar peg to a floating regime (sudden removal of capital controls and sudden increase in flexibility of the exchange rate): (A) => (D) => (D), and

(5) sudden shift from a dollar peg to a managed-floating regime (sudden removal of capital controls and sudden increase in flexibility of the exchange rate with occasional interventions): (A) => (D) => (E) => (D).

The first policy is maintaining a dollar peg (A). The monetary authority imposes capital controls and fixes a weight on the dollar rate at 1. The second policy includes a transition period (B), which reflects an adjustment period of capital controls and basket weights. This policy starts with a dollar peg and undergoes a transition period (B) and arrives at a basket peg without capital controls (C). The third policy does not include a transition period (B); therefore, the monetary authority shifts from a dollar peg to a basket peg without any interim period, implying the economy will suddenly jump to the desired basket peg (C). The fourth is that the monetary authority shifts from a dollar peg to a floating regime without a transition period (D), implying that the economy will suddenly jump to a floating regime. The fifth policy is that the monetary authority shifts from a dollar peg to a managed-floating regime without a transition period. Under a managed-floating regime, if the exchange rate fluctuation is significant, the monetary authority intervenes in the foreign exchange market to maintain the exchange rate at a constant rate (E). Otherwise, the monetary authority allows the exchange rate to fluctuate as long as the exchange rate does not deviate substantially from its desired level.

We assume that the time interval for the initial dollar peg is T_0. Furthermore, we regard the transition period as T_1 and the time interval after the authority reaches the target regime as T_2. We set a discount factor as β.

Throughout this section, we consider the case of the monetary authority aiming to minimize output fluctuations, which is shown as[21]

$$L(T_1, T_2) = \sum_{t=1}^{T_0+T_1+T_2} \beta^{t-1}(y_t - \bar{y}')^2 \tag{27}$$

[21] Current loss function (i.e., output stability or price level stability) is one of the conventional loss functions commonly used in the literature on monetary policy and exchange rate regimes. See Woodford (1999); Clarida, Gali, and Gertler (2001, 2002); Svensson (2000); and Walsh (2003) for more details. In the literature, none of the existing studies define stabilizing export growth as a policy objective for monetary authorities since exports are one component of gross domestic product (output). The recent literature (see, for example, Woodford 2003) derives a conventional loss function from optimization of the representative household. The traditional loss function is found to be an approximation of the level of expected utility of the representative household. An emerging stream of studies explores the welfare consequences of using a conventional loss function versus the microfounded loss function (see, for example, Paez-Farrell 2014). In the context of our analysis, the main benefit of using the microfounded loss function would be a potentially better measurement of welfare. But this comes at the cost of making it much harder and less precise to obtain measurements due to setting less established parameter values. Both 1 percentage point positive and negative deviations from potential output are treated symmetrically in the model, given that we measure the loss function in terms of the sum of squares of the deviations of output from potential output. This is because a positive deviation is also negatively influencing the economy as it often triggers high rates of consumer and asset price inflation.

Note that a reduced form $y_t - \bar{y}'$ varies depending on the exchange rate regime, as explained in section IV.B. Appendix 4 discusses the case of price stability.

A. Maintaining a Dollar Peg (1)

The economy continues with a dollar peg for the entire time period $T_0 + T_1 + T_2$. Its cumulative loss, given optimal interest rate i^*, is expressed as follows:

$$\begin{aligned} L_1(i^*, T_1 + T_2) &= \sum_{t=1}^{T_0} \beta^{t-1}(y_t - \bar{y}'_A)^2 + \sum_{t=T_0+1}^{T_0+T_1+T_2} \beta^{t-1}(y_t - \bar{\bar{y}}'_A)^2 \\ &= \sum_{t=1}^{T_0} \beta^{t-1}(y_t - \bar{y}'_A)^2 \\ &\quad + \sum_{t=T_0+1}^{T_0+T_1+T_2} \beta^{t-1} \left[\begin{array}{l} \left\{ A_1(t) + A'_1(t) \right\} \hat{e}_t^{EA/JPN} + A_2(t)\Delta\hat{e}_t^{EA/JPN} \\ \quad + A'_2(t)\Delta\hat{e}^{EA/US} + A_3(t) i_{t+1} \end{array} \right]^2 \end{aligned} \tag{28}$$

$$i^* = argmin \sum_{t=1}^{T_0+T_1+T_2} \beta^{t-1}(y_t - \bar{y}'_A)^2 \tag{28'}$$

Note that i^* is chosen to minimize the cumulative loss in terms of deviation from its stable equilibrium value under a dollar peg.

B. Gradual Adjustment to a Basket Peg without Capital Controls (2)

First, we denote an optimal basket weight as υ^*, assuming $0 \leq \upsilon^* \leq 1$. As explained above, the monetary authority starts by adopting a dollar peg with capital controls (A), indicating that its basket weight is equal to 1. Then, it shifts to a basket peg and gradually loses a degree of capital control under regime (B). Simultaneously, the monetary authority decreases its basket weight by $(1 - \upsilon^*)/T_1$ each period during the transition in order to arrive at a basket peg without capital controls. Once the monetary authority adopts the targeted basket peg, it maintains its optimal basket weight at υ^*. The cumulative loss of transition policy (2) with an optimal basket weight υ^* can be expressed as

$$\begin{aligned} &L_2(\upsilon^*, T_1, T_2) \\ &= \sum_{t=1}^{T_0} \beta^{t-1}(y_t - \bar{y}'_A)^2 + \sum_{t=T_0+1}^{T_0+T_1} \beta^{t-1}(y_t - \bar{y}'_B)^2 + \sum_{t=T_0+T_1+1}^{T_0+T_1+T_2} \beta^{t-1}(y_t - \bar{y}'_C)^2 \end{aligned}$$

$$= \sum_{t=1}^{T_0} \beta^{t-1}(y_t - \bar{y}'_A)^2 + \sum_{t=T_0+1}^{T_0+T_1} \beta^{t-1}\left[B_1(t)\upsilon(t)\hat{e}_t^{US/JPN} + B_2(t)\hat{e}_t^{US/JPN} + B_3(t)\hat{z}_t\right]^2$$

$$+ \sum_{t=T_0+T_1+1}^{T_0+T_1+T_2} \beta^{t-1}\left[C_1(t)\upsilon^*\hat{e}_t^{US/JPN} + C_2(t)\hat{e}_t^{US/JPN} + C_3(t)\hat{z}_t\right]^2 \quad (29)$$

where $(y_t - \bar{y}'_A) = A_1(t)\hat{e}_t^{EA/JPN} + A_2(t)\Delta\hat{e}_t^{EA/JPN} + A_3(t)i^*$ and $\upsilon(t) = 1 - \frac{1-\upsilon^*}{T_1}(t - T_0)$.

Note that the second and third terms on the right-hand side of Equation (29) show losses during transition periods and under the basket peg (C), respectively. The optimal weight is derived by minimizing the cumulative loss $L_2(\upsilon^*, T_1 + T_2)$ with respect to the weight υ^*:

$$\upsilon^* = \frac{-1}{H_1}\left[\sum_{t=T_0+T_1+1}^{T_0+T_1+T_2} \beta^{t-1}C_1(t)\hat{e}_t^{US/JPN}\left(C_2(t)\hat{e}_t^{US/JPN} + C_3(t)\hat{z}_t\right)\right.$$

$$\left. + \sum_{t=T_0+1}^{T_0+T_1} \beta^{t-1}B_1(t)\left(\frac{t-T_0}{T_1}\right)\hat{e}_t^{US/JPN}\left(\begin{array}{l} B_1(t)\left(\dfrac{t-T_0}{T_1}\right)\hat{e}_t^{US/JPN} \\ \\ + B_2(t)\hat{e}_t^{US/JPN} + B_3(t)\hat{z}_t \end{array}\right)\right] \quad (29')$$

where $H_1 = \left[\sum_{t=T_0+1}^{T_0+T_1} \beta^{t-1}\left(B_1(t)\left(\frac{t-T_0}{T_1}\right)\hat{e}_t^{US/JPN}\right)^2 + \sum_{t=T_0+T_1+1}^{T_0+T_1+T_2} \beta^{t-1}\left(C_1(t)\hat{e}_t^{US/JPN}\right)^2\right]$.

C. Sudden Shift to a Basket Peg without Capital Controls (3)

In this case, the monetary authority starts with a dollar peg with capital controls (A), implying that its basket weight is fixed at 1, and suddenly shifts to a basket peg by implementing an optimal weight (υ^{**}) without capital controls (C). The cumulative loss for policy (3) with the optimal basket weight υ^{**} and target regime period $T_1 + T_2$ is shown as

$$L_3\left(\upsilon^{**}, T_1 + T_2, \tilde{e}_t^{EA/US,2}\right) = \sum_{t=1}^{T_0} \beta^{t-1}(y_t - \bar{y}'_A)^2 + \sum_{t=T_0+1}^{T_0+T_1+T_2} \beta^{t-1}(y_t - \bar{y}'_C)^2$$

$$= \sum_{t=1}^{T_0} \beta^{t-1}(y_t - \bar{y}'_A)^2 + \sum_{t=T_0+1}^{T_0+T_1+T_2} \beta^{t-1}\left[C_1(t)\upsilon^{**}\hat{e}_t^{US/JPN}\right.$$

$$\left. + C_2(t)\hat{e}_t^{US/JPN} + C_3(t)\hat{z}_t\right]^2 \quad (30)$$

$$\upsilon^{**} = \frac{-1}{H_2}\left[\sum_{t=T_0+1}^{T_0+T_1+T_2} \beta^{t-1} C_1(t)\hat{e}_t^{US/JPN}\left(C_2(t)\hat{e}_t^{US/JPN} + C_3(t)\hat{z}_t\right)\right] \tag{30'}$$

where $(y_t - \bar{y}'_A) = A_1(t)\hat{e}_t^{US/JPN} + A_2(t)\Delta\hat{e}_t^{EA/JPN} + A_3(t)i^*$, $H_2 = \left[\sum_{t=T_0+T_1+1}^{T_0+T_1+T_2} \beta^{t-1}\left(C_1(t)\hat{e}_t^{US/JPN}\right)^2\right]$, $\tilde{e}_t^{EA/US,2} = \sum_{t=T_0+1}^{T_0+T_1+T_2} \beta^{t-1}\left(\hat{e}_t^{US/JPN}\right)^2$ denotes a sum of discounted squares of the US dollar rate. The impacts of exchange rate volatility after the shift are included in the second term on the right-hand side of Equation (30). When compared with the basket weight obtained in section V.B, υ^{**} is different from υ^* for as long as the transition period exists ($T_1 \neq 0$).

D. Sudden Shift from a Dollar Peg to a Floating Regime (4)

The monetary authority starts by adopting a dollar peg with capital controls (A) and it suddenly jumps to a floating regime without capital controls. The cumulative loss under policy (4) with an optimal money supply m^* and the target regime period $T_1 + T_2$ is shown as follows:

$$\begin{aligned} L_4\left(m^*, T_1+T_2, \tilde{e}_t^{EA/US,2}\right) &= \sum_{t=1}^{T_0} \beta^{t-1}(y_t - \bar{y}'_A)^2 + \sum_{t=T_0+1}^{T_0+T_1+T_2} \beta^{t-1}(y_t - \bar{y}'_D)^2 \\ &= \sum_{t=1}^{T_0} \beta^{t-1}(y_t - \bar{y}'_A)^2 + \sum_{t=T_0+1}^{T_0+T_1+T_2} \beta^{t-1}\big[D_1(t)\hat{e}_t^{US/JPN} \\ &\quad + D_2(t)\hat{z}_t + D_3(t)m^*\big]^2 \end{aligned} \tag{31}$$

$$m^* = \frac{-1}{H_3}\left[\sum_{t=T_0+1}^{T_0+T_1+T_2} \beta^{t-1} D_3(t)\hat{e}_t^{US/JPN}\left(D_1(t)\hat{e}_t^{US/JPN} + D_2(t)\hat{z}_t\right)\right] \tag{31'}$$

where $(y_t - \bar{y}'_A) = A_1(t)\hat{e}_t^{US/JPN} + A_2(t)\Delta\hat{e}_t^{EA/JPN} + A_3(t)i^*$ and $H_3 = \left[\sum_{t=T_0+T_1+1}^{T_0+T_1+T_2} \beta^{t-1}(D_3(t))^2\right]$.

The impacts of exchange rate volatility associated with the shift are included in the second term on the right-hand side of Equation (31).

E. Sudden Shift from a Dollar Peg to a Managed-Floating Regime (5)

Following the previous case, we denote the optimal money supply under the floating regime as m^{**}. The monetary authority starts by adopting a dollar peg

with capital controls (A) and it suddenly shifts to a floating regime without capital controls. Occasionally, when the US dollar rate fluctuates significantly, it intervenes in the foreign exchange market to maintain the rate at a constant level under perfect capital mobility (E). After the volatility of the US dollar rate moderates, it reverts to a free-floating regime. These interventions are implemented only temporarily to avoid large fluctuations in the exchange rate. The cumulative loss under policy (5) with whole period $T_1 + T_2$, period of floating T_D, and temporal period of a dollar peg (intervention period) T_E is shown as:

$$L_5\big(m^{**}, T_1+T_2, T_D, T_E, \tilde{e}_{t,E}^{R/\$,2}\big) = \sum_{t=1}^{T_0} \beta^{t-1}(y_t - \bar{y}'_A)^2 + \sum_{t=T_0+1}^{T_0+T_D} \beta^{t-1}(y_t - \bar{y}'_D)^2 + \sum_{t=T_0+T_D+1}^{T_0+T_D+T_E} \beta^{t-1}(y_t - \bar{y}'_E)^2 + \sum_{t=T_0+T_D+T_E+1}^{T_0+T_1+T_2} \beta^{t-1}(y_t - \bar{y}'_D)^2 \tag{32}$$

$$m^{**} = \frac{-1}{H_4}\left[\sum_{t=T_0+1}^{T_0+T_D} \beta^{t-1} D_3(t)\big(D_1(t)\hat{e}_t^{US/JPN} + D_2(t)\hat{z}_t\big) + \sum_{t=T_0+T_D+T_E+1}^{T_0+T_1+T_2} \beta^{t-1} D_3(t)\big(D_1(t)\hat{e}_t^{US/JPN} + D_2(t)\hat{z}_t\big)\right] \tag{32′}$$

where $(y_t - \bar{y}'_A) = A_1(t)\hat{e}_t^{EA/JPN} + A_2(t)\Delta\hat{e}_t^{EA/JPN} + A_3(t)i^*$, $(y_t - \bar{y}'_E) = A_1(t)\hat{e}_t^{EA/JPN} + A_2(t)\Delta\hat{e}_t^{EA/JPN} + A_3(t)i_{t+1}$ and $H_4 = \left[\sum_{t=T_0+1}^{T_0+T_D} \beta^{t-1}(D_3(t))^2 + \sum_{t=T_0+T_D+T_E+1}^{T_0+T_1+T_2} \beta^{t-1}(D_3(t))^2\right]$, $\tilde{e}_{t,E}^{EA/US,2} = \sum_{t=T_0+T_D+1}^{T_0+T_D+T_E} \beta^{t-1}\hat{e}_{t,E}^{EA/US,2}$ is defined as a sum of discounted squares of the US dollar rate during intervention periods. The impacts of the exchange rate volatility associated with the shift are included in the second term on the right-hand side of Equation (32). When compared with the optimal money supply obtained in section V.D, m^{**} is different from m^* for as long as the intervention period exists ($T_E \neq 0$).

VI. Comparison of Transition Policies

In this section, we consider the optimal policy for a monetary authority seeking to stabilize output fluctuations. As mentioned earlier, Appendix 4 provides a similar discussion with regard to price stability. Our discussion in this section centers on two questions: Is it desirable for the monetary authority to maintain a dollar peg over the long run? And, what would be an optimal policy if the authority

decides to deviate from the status quo? We advance our argument in three steps. First, we apply some implications from static analysis into this dynamic context. Then, we compare the cumulative loss of the current policy, (1), with other transition policies. After we find that maintaining a dollar peg is not the appropriate solution over the long run, we look for an optimal outcome for the monetary authority among the four transition policies.

A. Implications of Static Analysis

First, we reflect on some implications derived from static analysis. Using a static small open economy general equilibrium model, Yoshino, Kaji, and Suzuki (2004) show that it is less desirable for an economy to adopt a dollar peg than a basket peg or floating regime; the value of the welfare loss under a dollar peg is higher than under a basket peg or a floating regime at the steady state for one period.[22] We can express these implications by using a one-period loss in this model as follows:

$$\left(y_t - \bar{\bar{y}}'_A\right) > \left(y_t - \bar{y}'_C\right) \tag{33}$$

$$\left(y_t - \bar{\bar{y}}'_A\right) > \left(y_t - \bar{y}'_D\right) \tag{33'}$$

Note that these results hold under regimes that have been maintained for several periods.

B. Comparisons of Policy (1) and Other Transition Policies

We discuss the desirability of a dollar peg over the long run by comparing policy (1) and other transition policies to a basket peg and a floating regime. We start with a comparison between maintaining a dollar peg, policy (1), and a sudden shift to a basket peg without capital controls, policy (3). We define a threshold time period T_C^* such that

$$L_1(i^*, T_C^*) = L_3\left(\upsilon^{**}, T_C^*, \tilde{e}_t^{EA/US,2}\right)$$

expressing a time interval under which the cumulative loss of maintaining a dollar peg is equal to that of shifting suddenly to a basket peg. Taking into account that the above equation holds under the target regime period, we obtain the following statements:

$$L_1(i^*, t) < L_3\left(\upsilon^{**}, t, \tilde{e}_t^{EA/US,2}\right) \quad \text{if } t < T_C^* \tag{34}$$

$$L_1(i^*, t) > L_3\left(\upsilon^{**}, t, \tilde{e}_t^{EA/US,2}\right) \quad \text{if } t > T_C^* \tag{34'}$$

[22] Yoshino, Kaji, and Asonuma (2004) find that this is also the case for two small open economies, which are mutually dependent in a static analysis.

This means that if t is shorter than the threshold time period T_C^*, then the cumulative loss of maintaining a dollar peg is smaller than that of transitioning to a basket peg. This could happen only if the exchange rate volatility negatively affects the economy.[23] However, if t is longer than the threshold time period T_C^*, then a cumulative loss of maintaining a dollar peg is higher than a sudden shift to a desired basket peg. The longer the time period for adopting a basket peg, the more benefits the economy will obtain from shifting to a basket peg, as shown in Equation (34′).

Next, we compare the losses under maintaining a dollar peg, policy (1) to shifting to a floating regime, policy (4). We define a threshold time period T_D^* such that

$$L_1(i^*, T_D^*) = L_4\left(m^*, T_D^*, \tilde{e}_t^{EA/US,2}\right)$$

denoting the time interval under which the cumulative loss of maintaining a dollar peg is equal to that of shifting to a floating regime. Reflecting that the above equation holds under the target regime period after the shift, the following conditions hold:

$$L_1(i^*, t) < L_4\left(m^*, t, \tilde{e}_t^{EA/US,2}\right) \quad \text{if } t < T_D^* \tag{35}$$

$$L_1(i^*, t) > L_4\left(m^*, t, \tilde{e}_t^{EA/US,2}\right) \quad \text{if } t > T_D^* \tag{35′}$$

These findings imply that the longer the period of adopting a floating regime, the greater the benefits to the economy from shifting to a floating regime as shown in Equation (35′). Summarizing the above results, maintaining a dollar peg is desirable only in the short-term (i.e., $t < min[T_C^*, T_D^*]$). As the target time period is extended, the economy can realize greater benefits from shifting to either a basket peg or a floating regime.

C. Comparisons among Transition Policies

We then identify an optimal policy among the four transition policies. There are benefits and costs for each of the four transition policies (2), (3), (4), and (5) as shown in Table 4.[24]

These benefits and costs are taken into account by evaluating the cumulative losses expressed by Equations (29), (30), and (31). By comparing cumulative losses, we can analyze an optimal transition policy if the monetary authority should decide to shift from a dollar peg.

[23] As explained in section V.C, the effect of exchange rate volatility due to the shift is included in the expression of the cumulative loss under policy (3). Therefore, when the length of time under the target regime is short, the loss of maintaining the current regime is smaller than that of policy (3) because the monetary authority can avoid the negative effects of exchange rate volatility associated with the shift.

[24] For components of costs, estimates based on numerical analysis for the PRC and Thailand are provided in Appendix 5.

Table 4. **Benefits and Costs of Transition Policies**

Policy	Benefits	Costs
(1) Maintaining a dollar peg	No volatility of $e^{EA/US}$	Limited capital inflows
(2) Gradually shifting to a basket peg	Small volatility of i	Time required to reach stable regime
	Small volatility of $e^{EA/US}$, $e^{EA/JPN}$	
	Small deviations of $e^{EA/US,e}$, $e^{EA/JPN,e}$	Adjustment costs
(3) Suddenly shifting to a basket peg	Stable regime achieved immediately (higher benefits under stable regime)	High volatility of i
	No adjustment costs	High volatility of $e^{EA/US}$, $e^{EA/JPN}$
	Small deviations of $e^{EA/US,e}$, $e^{EA/JPN,e}$	
(4) Suddenly shifting to a free-floating regime	Stable regime achieved immediately (higher benefits under desirable regime)	High volatility of i
	No adjustment costs	High volatility of $e^{EA/US}$, $e^{EA/JPN}$
		Large deviations of $e^{EA/US,e}$, $e^{EA/JPN,e}$
(5) Suddenly shifting to a managed-floating regime	Stable regime achieved immediately (higher benefits under desirable regime)	High volatility of i
	No adjustment costs	No monetary policy autonomy during interventions
	Limited exchange rate fluctuations	

Source: Authors' compilation.

We start by comparing a gradual adjustment to a basket peg, policy (2), and a sudden shift to a basket peg, policy (3). Given time period T_2, we define T_1^* such that

$$L_2(\upsilon^*, T_1^*, T_2) = L_3\left(\upsilon^{**}, T_1^* + T_2, \tilde{e}_t^{EA/US,2}\right)$$

reflecting a time interval for the transition period under which the cumulative loss of a gradual adjustment policy is equal to a sudden shift to a basket peg.

Based on the fact that terms in $L_3(\upsilon^{**}, T_1^* + T_2)$ include highly volatile exchange rates and interest rates due to the shift, it is apparent that the following results will hold:

$$L_2(\upsilon^*, T_1, T_2) < L_3\left(\upsilon^{**}, T_1 + T_2, \tilde{e}_t^{EA/US,2}\right) \quad \textit{if } T_1 < T_1^* \tag{36}$$

$$L_2(\upsilon^*, T_1, T_2) > L_3\left(\upsilon^{**}, T_1 + T_2, \tilde{e}_t^{EA/US,2}\right) \quad \textit{if } T_1 > T_1^* \tag{36'}$$

This implies that the longer the transition period of adjustment, the more benefits will accrue from reaching the target regime suddenly. However, as long as the interval for the transition period is in the range, $T_1 < T_1^*$, the monetary authority will benefit from avoiding large exchange rate fluctuations.

Next, we consider a contrast between policy (3) and policy (4). Instead of explicit conditions for the time intervals, we obtain theoretical conditions on exchange rate volatility. Given time periods T_1 and T_2, the optimal basket weight υ^{**}, and money supply m^*, we define $\tilde{e}_t^{EA/US,2^*}$ such that

$$L_3\left(\upsilon^{**}, T_1 + T_2, \tilde{e}_t^{EA/US,2^*}\right) = L_4\left(m^*, T_1 + T_2, \tilde{e}_t^{EA/US,2^*}\right)$$

reflecting a sum of discounted squares of the US dollar rate in which the cumulative loss of shifting to a basket peg is equal to that of a sudden shift to a floating regime. If the US dollar rate fluctuates significantly, the economy benefits from committing to a basket peg by stabilizing the negative impacts of exchange rate fluctuations on trade and capital flows, and minimizing unexpected deviations from exchange rate expectations. Thus, the following statements hold:

$$L_3\left(\upsilon^{**}, T_1 + T_2, \tilde{e}_t^{EA/US,2}\right) < L_4\left(m^*, T_1 + T_2, \tilde{e}_t^{EA/US,2}\right) \quad \text{if } \tilde{e}_t^{EA/US,2} > \tilde{e}_t^{EA/US,2^*} \tag{37}$$

$$L_3\left(\upsilon^{**}, T_1 + T_2, \tilde{e}_t^{EA/US,2}\right) > L_4\left(m^*, T_1 + T_2, \tilde{e}_t^{EA/US,2}\right) \quad \text{if } \tilde{e}_t^{EA/US,2} < \tilde{e}_t^{EA/US,2^*} \tag{37'}$$

These statements show that the economy will be better off choosing a sudden shift to a basket peg rather than to a floating regime, given the large exchange rate fluctuations. However, if the magnitude of the exchange rate fluctuations is relatively modest, the monetary authority would be better off adopting a floating regime.

Finally, we consider whether it is desirable to shift to a managed-floating regime, policy (5), rather than a free-floating regime, policy (4). Given time period $T_1 + T_2$, T_D, T_E, money supply m^* and m^{**}, and exchange rate volatility for the whole period $\tilde{e}_t^{EA/US,2}$, we define the exchange rate volatility for intervention periods $\tilde{e}_{t,E}^{EA/US,2^{**}}$:

$$L_5\left(m^{**}, T_1 + T_2, T_D, T_E, \tilde{e}_{t,E}^{EA/US,2^{**}}\right) = L_4\left(m^*, T_1 + T_2, \tilde{e}_t^{EA/US,2^{**}}\right)$$

reflecting a sum of discounted squares of the US dollar rate during intervention periods in which the cumulative loss of shifting to a managed-floating regime is equal to that of a shift to a free-floating regime. If the exchange rate fluctuates significantly during the short periods, the economy will be better off intervening to avoid the negative impacts of the exchange rate swing on trade and capital flows. This can be expressed as

$$\begin{aligned} &L_5\left(m^{**}, T_1 + T_2, T_D, T_E, \tilde{e}_{t,E}^{EA/US,2}\right) \\ &\quad < L_4\left(m^*, T_1 + T_2, \tilde{e}_t^{EA/US,2}\right) \quad \text{if } \tilde{e}_{t,E}^{EA/US,2} > \tilde{e}_{t,E}^{EA/US,2^{**}} \end{aligned} \tag{38}$$

$$L_5\left(m^{**}, T_1 + T_2, T_D, T_E, \tilde{e}_{t,E}^{EA/US,2}\right)$$
$$> L_4\left(m^{*}, T_1 + T_2, \tilde{e}_{t}^{EA/US,2}\right) \quad \text{if } \tilde{e}_{t,E}^{EA/US,2} < \tilde{e}_{t,E}^{EA/US,2^{**}} \tag{38′}$$

Thus, it is desirable for the economy to shift to a managed-floating rather than to a free-floating regime, given the large exchange rate fluctuations during the short periods of interventions. However, if the magnitude of the exchange rate fluctuations during these intervention periods is relatively small, the economy would be better off shifting to a free-floating regime to take advantage of having monetary policy autonomy for the whole period. When comparing shifts to a basket peg or a managed-floating regime, we are not able to derive explicit theoretical conditions on time intervals. Instead, we rely on the quantitative estimates explained in section VII.

Summarizing these results, when choosing between policy (2) and policy (3), the longer the transition period of the adjustment, the more benefits the monetary authority will gain from immediately implementing a basket peg. When comparing sudden shifts to either a basket peg, policy (3), or a free-floating regime, policy (4), the welfare gains to the economy are greater under a shift to a basket peg if the exchange rate fluctuations are large. Similarly, if we compare between a sudden shift to a managed-floating regime, policy (5), and a free-floating regime, policy (4), the economy would be better off shifting to a managed-floating regime, given the large exchange rate fluctuations during the short intervention periods.

VII. Simulation Exercises for the People's Republic of China and Thailand

In this section, we report simulation exercises using data for the PRC and Thailand. To accurately determine cumulative losses over specified periods, we use both estimated coefficients and actual exchange rate and exchange rate risk shocks specific to the PRC and Thailand.[25] We quantify cumulative losses for the four transition policies and maintaining the status quo. Our quantitative results support the theoretical findings explained in sections VI.B and VI.C. First, among the five policies, maintaining a dollar peg, policy (1), leads to the greatest losses, i.e., the least desirable policy in both the PRC and Thai cases. Second, when contrasting two transition policies to a basket-peg regime, a gradual adjustment rather than a sudden shift is desirable in both economies. Finally, when comparing a shift to a basket peg with a shift to a floating regime, it is better to shift to a basket peg in Thailand for both output and price level stability. In contrast, the optimal policy is dependent upon policy objective in the PRC.

[25] An alternative method is to take commonly used parameters that are not specific to the PRC and Thailand and draw shocks from specified distributions. Then, for robustness, we apply sensitivity analysis. The cases of Malaysia and Singapore are discussed in Yoshino, Kaji, and Asonuma (2015b).

A. Data and Regression Results

We use Chinese and Thai quarterly data from the IMF's *International Financial Statistics*.[26] All variables except interest rates are defined in natural logs. For exchange rate risk, we use the variance of monthly exchange rate data as a proxy. Applying the Dicky–Fuller generalized least squares (DF-GLS) unit root tests, we find some variables have unit roots. Then we move onto Johansen cointegration tests (Johansen 1992, 1995) and prove that all variables in both the Chinese and Thai samples are stationary.[27] We apply the instrumental variable method to estimate coefficients of the model simultaneously with instruments of lagged variables, which are predetermined. We differentiate between two sample periods in each economy based on the exchange rate regime. For the PRC, the two periods are Q1 1999–Q2 2005 for a dollar peg and Q3 2005–Q4 2010 for a floating regime.[28] As the PRC has never adopted a de facto floating regime, we use estimated coefficients obtained for a de facto basket-peg period. For Thailand, we set Q1 1993–Q2 1997 as the period for both a dollar peg and a basket peg, and Q3 1997–Q1 2006 for a floating regime.[29] A dummy variable is used to exclude impacts of the 1997/98 Asian financial crisis (Q3 1997–Q2 1998) for the Thai case (floating regime). Table 5 reports the estimation results on the basis of the macroeconomic model explained in section IV.A.

B. Simulation Results Using Estimated Coefficients for the People's Republic of China and Thailand

Our simulation algorithm is reported in Appendix 7. We quantify optimal values of instruments and of cumulative losses according to the transition policies. For the exchange rates and exchange rate risks, we use the actual data for Q1 1999–Q4 2010 for the PRC and Q1 1993–Q1 2006 for Thailand. As we define exogenous shocks and other variables as deviations from the long-run values, we use the deviation from the Hodrick–Prescott filtered trend values. We assume the time period for the dollar peg as 1 quarter ($T_0 = 1$), the interval for the transition period as 18 quarters ($T_1 = 18$), and the period for the target regime as 18 quarters ($T_2 = 18$).[30] Tables 6 and 7 report the values for cumulative losses and optimal instruments for stabilizing output and price levels, respectively, for each of the five policies for both the PRC and Thailand. The optimal instrument values correspond to what we obtained theoretically in section VI.A–VI.E. Cumulative losses are reported

[26] For more details on the data, see Appendix 6.

[27] Results of unit root tests and cointegration tests are reported in Appendix 6.

[28] Yoshino, Kaji, and Asonuma (2014) find empirically that the estimated weight of the US dollar rate in the currency basket of the PRC decreased from 1.0 to 0.82 over the sample period.

[29] The sample of observations under a dollar peg and a basket peg is slightly limited due to a de facto dollar peg in Thailand.

[30] Appendix 8 explores the optimal basket weights under different time intervals for policies (2) and (3).

Table 5. **Estimation Results for the People's Republic of China and Thailand**

	People's Republic of China		Thailand	
Coefficients Sample	**Fixed (basket peg) Q1 1999–Q2 2005**	**Floating[a] Q3 2005–Q4 2010**	**Fixed (basket peg) Q1 1993–Q2 1997**	**Floating Q3 1997–Q1 2006**
λ	N.A.	0.26*** (0.09)	N.A.	0.51** (0.07)
σ	N.A.	0.05** (0.03)	N.A.	0.006 (0.02)
ε	3.20*** (0.89)	10.13*** (1.89)	0.05 (0.08)	1.70** (0.82)
ϕ	0.23*** (0.05)	0.50*** (0.10)	0.94*** (0.19)	0.44 (0.36)
δ, δ'	−1.20 (2.51)	1.27* (0.69)	−0.73*** (0.08)	0.01 (0.10)
θ, θ'	0.70** (0.33)	−0.007 (0.42)	0.27*** (0.07)	−0.005 (0.08)
ρ	−0.52 (0.38)	0.63** (0.25)	−3.73*** (0.50)	1.13*** (0.34)
τ	−36.11 (46.78)	−0.14 (0.77)	0.05 (0.22)	0.002 (0.009)
ς	0.40 (1.50)	8.66 (15.91)	−2.00 (2.55)	0.53 (0.94)
α	0.16*** (0.02)	0.13*** (0.04)	0.01*** (0.003)	0.007*** (0.001)
ψ	−0.04* (0.02)	0.12** (0.005)	−0.25*** (0.04)	0.20*** (0.05)
η, η'	−0.06* (0.03)	−0.15** (0.07)	−0.19*** (0.03)	0.02 (0.02)
μ, μ'	−1.32*** (0.26)	−0.35*** (0.11)	0.07*** (0.02)	0.02 (0.02)
χ	−7.28** (3.13)	−0.001 (0.14)	0.01 (0.06)	0.002 (0.002)
ξ	−5.87*** (0.88)	−7.80*** (2.80)	−0.55 (0.66)	−0.30 (0.23)

N.A. = not applicable.
Notes:
[a]As the PRC has never adopted a de facto floating regime, we use estimated coefficients for a de facto basket-peg period.
*** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.
Source: Authors' calculations.

Table 6. **Cumulatative Losses—Output Stability**

A. People's Republic of China

	Policy (1)	**Policy (2)**	**Policy (3)**	**Policy (4)**	**Policy (5) ($T_E = 5$)[a]**
Stable regime	Dollar peg	Basket peg	Basket peg	Floating	Managed floating
Adjustment	N.A.	Gradual	Sudden	Sudden	Sudden
Optimal instrument value	$i^* = 4.34$	$\upsilon^* = 0.58$	$\upsilon^{**} = 0.68$	$m^* = 0.016$	$m^{**} = 0.017$
Cumulative loss (value)	17.04	1.80	1.91	2.67	2.31
Cumulative loss (% of $\bar{y}^2$)[b]	23.4	2.4	2.6	3.7	3.2

B. Thailand

	Policy (1)	**Policy (2)**	**Policy (3)**	**Policy (4)**	**Policy (5) ($T_E = 5$)[c]**
Stable regime	Dollar peg	Basket peg	Basket peg	Floating	Managed floating
Adjustment	N.A.	Gradual	Sudden	Sudden	Sudden
Optimal instrument value	$i^* = 0.003$	$\upsilon^* = 0.68$	$\upsilon^{**} = 0.62$	$m^* = 0.082$	$m^{**} = 0.082$
Cumulative loss (value)	0.0069	0.0006	0.0026	0.0052	0.0053
Cumulative loss (% of $\bar{y}^2$)[d]	15.0	1.3	5.7	11.3	11.5

N.A. = not applicable.
Notes:
[a]If $T_E = 7$, the cumulative loss is 3.54 ($m^* = 0.017$).
[b]We calculate the value of $\bar{y}^2$ and obtain $\bar{y}^2 = 72.8$.
[c]If $T_E = 5$, the cumulative loss is 3.54 ($m^{**} = 0.082$).
[d]We calculate the value of $\bar{y}^2$ and obtain $\bar{y}^2 = 0.046$.
Source: Authors' calculations.

Table 7. **Cumulatative Losses—Price Stability**

A. People's Republic of China

	Policy (1)	**Policy (2)**	**Policy (3)**	**Policy (4)**	**Policy (5) ($T_E = 5$)**[a]
Stable regime	Dollar peg	Basket peg	Basket peg	Floating	Managed floating
Adjustment	N.A.	Gradual	Sudden	Sudden	Sudden
Optimal instrument value	$i^* = 1.14$	$\upsilon^* = 0.65$	$\upsilon^{**} = 0.78$	$m^* = 0.11$	$m^{**} = 0.01$
Cumulative loss (value)	0.30	0.020	0.021	0.013	0.033
Cumulative loss (% of $\bar{p}^2$)[b]	33.0	2.2	2.3	1.4	3.3

B. Thailand

	Policy (1)	**Policy (2)**	**Policy (3)**	**Policy (4)**	**Policy (5) ($T_E = 3$)**[c]
Stable regime	Dollar peg	Basket peg	Basket peg	Floating	Managed floating
Adjustment	N.A.	Gradual	Sudden	Sudden	Sudden
Optimal instrument value	$i^* = 0.00005$	$\upsilon^* = 0.14$	$\upsilon^{**} = 0.59$	$m^* = 0.0011$	$m^{**} = 0.0019$
Cumulative loss (value)	0.0044	0.0022	0.0028	0.0038	0.0033
Cumulative loss (% of $\bar{p}^2$)[d]	5.6	2.8	3.6	4.8	4.2

N.A. = not applicable.
Notes:
[a]If $T_E = 7$, the cumulative loss is 3.54 ($m^* = 0.015$).
[b]We calculate the value of $\bar{p}^2$ and obtain $\bar{p}^2 = 0.91$.
[c]If $T_E = 5$, the cumulative loss is 0.0033 ($m^{**} = 0.0024$).
[d]We calculate the value of $\bar{p}^2$ and obtain $\bar{p}^2 = 0.079$.
Source: Authors' calculations.

in both absolute terms and as a percentage of squared steady-state values ($\bar{y}^2$ and $\bar{p}^2$).

Tables 6 and 7 confirm the theoretical findings discussed in section VI.B–VI.C. First, among the five policies, maintaining the dollar peg, policy (1), leads to the greatest loss in terms of both stabilizing output and the price level in the PRC and Thailand. This is because capital controls limit capital inflows and hinder successful growth over the medium and long run. The results imply that these economies would be better off shifting to a target basket peg or a floating regime.

Second, comparing the two transition policies to a basket peg, it is desirable in terms of stabilizing output and the price level for both the PRC and Thailand to pursue a gradual adjustment rather than a sudden shift. Volatility in interest rates associated with a sudden shift is substantially high and dampens output. On the contrary, setting the interval of transition that is long enough helps mitigate the volatility of interest rates associated with a gradual shift. Moreover, the optimal weights of policy (2) and policy (3) are different, as explained in section V.B–V.C.[31] Third, when comparing shifting to a basket peg with shifting to a floating regime in Thailand, shifting to a floating regime leads to greater losses, suggesting that the economy would be better off shifting to the desired basket peg for both stabilizing

[31]The optimal basket weights that we identify for the PRC and Thailand are different from those in Ogawa and Shimizu (2006), which were calculated based on shares of regional gross domestic product (measured at purchasing power parity) and trade volume shares.

output and the price level. As mentioned in section VI.C, this is a case in which the economy can experience the benefits of committing to a basket peg by smoothing the negative impacts of exchange rate fluctuations and following exchange rate expectations. In the case of the PRC, the results are mixed and depend on policy goals. If the monetary authority prefers to stabilize output, it would be better off shifting to the desired basket peg. However, if the monetary authority chooses price level stability, its decision should be to shift to a floating regime. This is because unlike the choice to stabilize output, there are fewer negative impacts on domestic prices associated with exchange rate fluctuations.

Finally, a shift to a managed-floating regime is less desirable than a move to a basket peg. For Thailand, this is true in terms of both output and price level stability. This is the case for the PRC as well since shifting to a managed-floating regime results in greater losses than shifting to a basket peg. A basket peg is preferable because interventions in the foreign exchange market under a managed-floating regime lead to greater losses resulting from the lack of monetary policy autonomy for the monetary authorities during intervention periods.

VIII. Conclusions

Given observed shifts in exchange rate regimes in emerging market economies, particularly in East Asia, we attempt to overcome the limitations in static and conventional dynamic analyses. Our paper proposes a new dynamic transition analysis on the basis of a small open economy DSGE model. Our proposed analysis differs from existing analyses in that it explicitly explores shifts from a fixed exchange rate regime to a basket peg or a floating rate. We consider four transition policies, as well as maintaining the status quo, and obtain theoretical expressions for the cumulative loss and optimal instrument for each policy.

Our dynamic transition analysis using data for the PRC and Thailand draws the following findings. First, maintaining a dollar peg is found to be desirable only over the short run, indicating that an economy will be better off shifting to either a basket peg or a floating regime over the long run. Second, given the choice between a gradual adjustment, policy (2), toward the target basket peg or a sudden shift to the target basket peg, policy (3), greater benefits accrue to the economy from a gradual adjustment over a longer transition period. Third, given the comparison between sudden shifts to a basket peg, policy (3), or to a floating regime, policy (4), the welfare gains to the economy are maximized under a shift to a basket peg if the exchange rate fluctuates significantly. Finally, it is less desirable to adopt a shift to a managed-floating regime than to move to a free-floating regime as the monetary authority lacks monetary policy autonomy during interventions periods.

However, current analysis is still limited to a medium-run perspective rather than a long-run perspective of 20 years or more. There is a possibility that an

economy would be better off adopting a floating regime over the longer horizon (20–40 years). If this were the case, the question of whether an economy opts to take a one-stage shift (directly to a floating rate) or a two-stage shift (with a basket peg as an intermediate regime) will remain a future research topic.

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*ADB recognizes "China" as the People's Republic of China and "Hong Kong" as Hong Kong, China.

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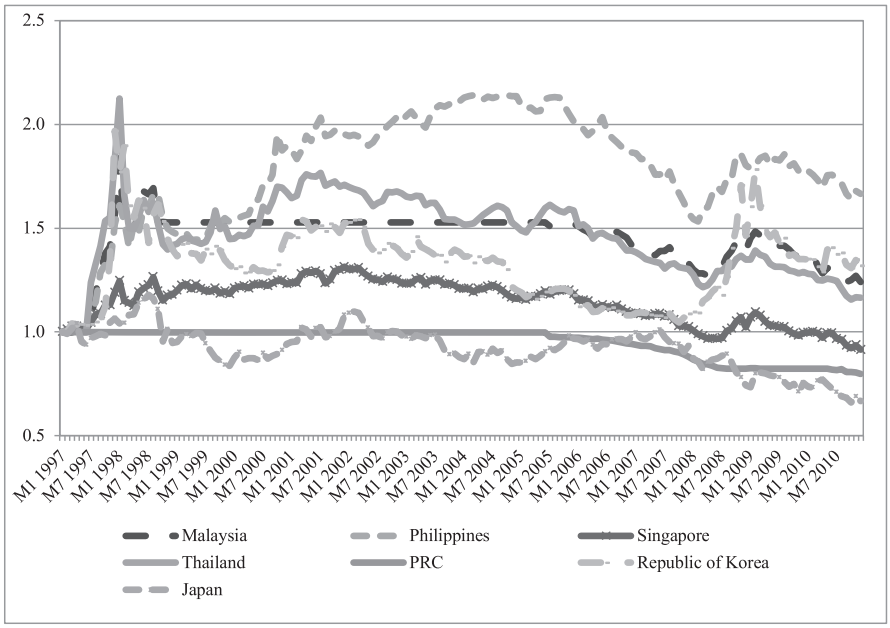
APPENDIX

Appendix 1. De Jure Exchange Rate Regime and Capital Account Measures

Figure A1. **Nominal Exchange Rates of ASEAN+3 Currencies against the US Dollar**
(January 1997 = 1, excluding Indonesia)



ASEAN+3 = Association of Southeast Asian Nations plus the People's Republic of China; Japan; and the Republic of Korea; PRC = People's Republic of China; US = United States.
Source: International Monetary Fund. 2015. *International Financial Statistics*. Washington, DC.

Table A.1. **Transition of De Facto Exchange Rate Regimes in ASEAN+3**[a,b]

Economy	1999	2002	2005	2008
People's Republic of China	De facto peg	De facto peg	Moving band that is narrower than or equal to +/–2%	De facto peg
Indonesia	Managed floating	Managed floating	De facto crawling band that is narrower than or equal to +/–5%	De facto crawling band that is narrower than or equal to +/–5%
Japan	Free floating	Free floating	Free floating	Free floating
Republic of Korea	Managed floating	Managed floating	Managed floating	Managed floating
Malaysia	Preannounced peg or currency board arrangement	Preannounced peg or currency board arrangement	De facto peg	De facto crawling band that is narrower than or equal to +/–5%

Continued.

Table A.1. *Continued.*

Economy	1999	2002	2005	2008
Philippines	De facto crawling band that is narrower than or equal to +/–2%	De facto crawling band that is narrower than or equal to +/–2%	De facto crawling band that is narrower than or equal to +/–2%	De facto crawling band that is narrower than or equal to +/–5%
Singapore	Moving band that is narrower than or equal to +/–2%	Moving band that is narrower than or equal to +/–2%	Moving band that is narrower than or equal to +/–2%	Moving band that is narrower than or equal to +/–2%
Thailand	Moving band that is narrower than or equal to +/–2%	Moving band that is narrower than or equal to +/–2%	Moving band that is narrower than or equal to +/–2%	Moving band that is narrower than or equal to +/–2%

ASEAN+3 = Association of Southeast Asian Nations plus the People's Republic of China; Japan; and the Republic of Korea.

[a]The categories of de facto exchange rate arrangements are (1) no separate legal tender, (2) preannounced peg or currency board arrangement, (3) preannounced horizontal band that is narrower than or equal to +/–2%, (4) de facto peg, (5) preannounced crawling peg, (6) preannounced crawling band that is narrower than or equal to +/–2%, (7) de facto crawling peg, (8) de facto crawling band that is narrower than or equal to +/–2%, (9) preannounced crawling band that is wider than or equal to +/–2%, (10) de facto crawling band that is narrower than or equal to +/–5%, (11) moving band that is narrower than or equal to +/–2%, (12) managed-floating regime, (13) free-floating regime, (14) free falling, and (15) dual market in which parallel market data is missing.

[b]According to Ilzetzki, Reinhart, and Rogoff (Unpublished), if the exchange rate has no drift, it is classified as a fixed parity; if a positive drift is present, it is labeled a crawling peg; and, if the exchange rate also goes through periods of both appreciation and depreciation it is a moving peg. If a band is explicitly announced and the chronologies show a unified exchange market, we label the episode as a band. By computing the probability that the monthly exchange rate change remains within a +/–2% band over a rolling 5-year period, the regime is classified as a de facto narrow band, a narrow crawling or a moving band over the period through which it remains continuously above the 80% threshold.

Source: Ilzetzki, E., C. Reinhart, and K. Rogoff. Exchange Rate Arrangements Entering the 21st Century: Which Anchor Will Hold? London: London School of Economics. Unpublished.

Appendix 2. Solving for Rational Expectations

A. Dollar-Peg Regime (A)

Substituting Equation (10) into Equation (3), we obtain the following equation such that

$$y_t - \bar{y}'_A = \frac{-(\delta+\theta)}{D}\begin{bmatrix}\psi\theta\hat{e}_t^{US/JPN} + (1+\psi\rho)\left(\hat{p}_{t+1}^e - \hat{p}_t^e\right) \\ -\hat{\alpha}_t - \psi\rho i_{t+1} - \psi\varsigma\Delta\hat{e}_t^{EA/JPN}\end{bmatrix}[1-\{1-\psi(\delta+\theta)-\eta\}^t]$$
$$+\theta\hat{e}_t^{US/JPN} + \rho\left(\hat{p}_{t+1}^e - \hat{p}_t^e\right) - \varsigma\Delta\hat{e}_t^{EA/JPN} - \rho i_{t+1} \quad \text{(A1)}$$

We take the expectation for both sides of Equation (6) and solve for $\hat{p}_{t+1}^e$:[32]

$$\hat{p}_{t+1}^e = a_1\hat{e}_t^{US/JPN} + a_2\hat{p}_t^e \quad \text{(A2)}$$

[32]We assume that exchange rate risk terms have a mean of zero, implying $E(\Delta\hat{e}_t^{EA/US}) = 0$ and $E(\Delta\hat{e}_t^{EA/JPN}) = 0$.

Then, we substitute for $\hat{p}^e_{t+1}$ in Equation (6) and obtain an expression for $\hat{p}^e_t$ such that

$$\hat{p}^e_t = a_3 \hat{e}^{US/JPN}_t \tag{A3}$$

Substituting Equations (A2) and (A3) into Equations (A1) and (10), respectively, we obtain

$$(y_t - \bar{y}'_A) = A_1(t)\hat{e}^{EA/JPN}_t + A_2(t)\Delta\hat{e}^{EA/JPN}_t + A_3(t)i_{t+1} \tag{11}$$

$$(p_t - \bar{p}'_A) = A^p_1(t)\hat{e}^{EA/JPN}_t + A^p_2(t)\Delta\hat{e}^{EA/JPN}_t + A^p_3(t)i_{t+1} \tag{11a}$$

where

$$A_1(t) = -\frac{-(\delta+\theta)[\psi\theta + (1+\psi\rho)(a_1 + a_2a_3 - a_2)]}{D}[1 - \{1 - \psi(\delta+\theta) - \eta\}^t] + \theta + \rho(a_1 + a_2a_3 - a_2)$$

$$A_2(t) = -\frac{-\psi\varsigma(\delta+\theta)}{D}[1 - \{1 - \psi(\delta+\theta) - \eta\}^t] - \varsigma$$

$$A_3(t) = -\frac{-\psi\rho(\delta+\theta)}{D}[1 - \{1 - \psi(\delta+\theta) - \eta\}^t] - \rho$$

$$A^p_1(t) = -\frac{-[\psi\theta + (1+\psi\rho)(a_1 + a_2a_3 - a_2)]}{D}[1 - \{1 - \psi(\delta+\theta) - \eta\}^t]$$

$$A^p_2(t) = -\frac{-\psi\varsigma}{D}[1 - \{1 - \psi(\delta+\theta) - \eta\}^t],$$

$$A^p_3(t) = -\frac{-\psi\rho}{D}[1 - \{1 - \psi(\delta+\theta) - \eta\}^t]$$

B. Basket-Peg Regime with Weak Capital Controls (B)

Substituting Equation (13) into Equation (3), we obtain the following equation:

$$\begin{aligned} y_t - \bar{y}'_B = \frac{-(\delta+\theta)}{D}\Big[\bar{G}\hat{e}^{US/JPN}_t + (1+\psi\rho)\big(\hat{p}^e_{t+1} - \hat{p}^e_t\big) \\ - (\psi\tau - \chi)\Delta\hat{e}^{EA/US}_t - \psi\varsigma\Delta\hat{e}^{EA/JPN}_t\Big] \\ \times [1 - \{1 - \psi(\delta+\theta) - \eta\}^t] + \{-\delta(1-\upsilon)\theta + \theta\upsilon\}\hat{e}^{US/JPN}_t \\ - \rho[1 - (1-\lambda)^t](1-\upsilon)\sigma\hat{e}^{US/JPN}_t + \rho\big(\hat{p}^e_{t+1} - \hat{p}^e_t\big) - \tau\Delta\hat{e}^{EA/US}_t \\ - \varsigma\Delta\hat{e}^{EA/JPN}_t \end{aligned} \tag{A4}$$

where $\bar{G} = [\psi\{\theta\upsilon - \delta(1-\upsilon) - \rho\lambda(1+\sigma)(1-\upsilon)\} - \eta(1-\upsilon)]$.

We take the expectation for both sides of Equation (13) and solve for $\hat{p}^e_{t+1}$:

$$\hat{p}^e_{t+1} = (b_1\upsilon + b'_1)\hat{e}^{US/JPN}_t + b_2\hat{p}^e_t \tag{A5}$$

Then, we substitute for $\hat{p}^e_{t+1}$ in Equation (13) and obtain an expression for $\hat{p}^e_t$ such that

$$\hat{p}^e_t = (b_3\upsilon + b'_3)\hat{e}^{US/JPN}_t \tag{A6}$$

Substituting Equations (A5) and (A6) into Equations (A4) and (13), we obtain

$$(y_t - \bar{y}'_B) = B_1(t)\upsilon\hat{e}^{US/JPN}_t + B_2(t)\hat{e}^{US/JPN}_t + B_3(t)\hat{z}_t \tag{17}$$

$$(p_t - \bar{p}'_B) = B^p_1(t)\upsilon\hat{e}^{US/JPN}_t + B^p_2(t)\hat{e}^{US/JPN}_t + B^p_3(t)\hat{z}_t \tag{17a}$$

where

$$B_1(t) = \frac{-(\delta+\theta)}{D}\left\{\begin{bmatrix}\eta + \psi(\theta+\delta+\rho\lambda(1+\sigma)) \\ +(1+\psi\rho)(b_1+b_2b_3-b_3)\end{bmatrix}\right\}[1-\{1-\psi(\delta+\theta)-\eta\}^t]$$
$$+(\delta+\theta)+\rho\sigma[1-(1-\lambda)^t]+\rho(b_1+b_2b_3-b_2)$$

$$B_2(t) = \frac{-(\delta+\theta)}{D}\left\{\begin{bmatrix}-\eta + \psi(-\delta-\rho\lambda(1+\sigma)) \\ +(1+\psi\rho)(b'_1+b_2b'_3-b'_3)\end{bmatrix}\right\}[1-\{1-\psi(\delta+\theta)-\eta\}^t]$$
$$-\delta-\rho\sigma[1-(1-\lambda)^t]+\rho(b'_1+b_2b'_3-b'_3)$$

$$B_3(t)\hat{z}_t = \frac{(\delta+\theta)}{D}\left\{\begin{matrix}(\psi\tau-\chi)\Delta\hat{e}^{\frac{EA}{US}}_t \\ +\psi\varsigma\Delta\hat{e}^{\frac{EA}{JPN}}_t\end{matrix}\right\}[1-\{1-\psi(\delta+\theta)-\eta\}^t]-\tau\Delta\hat{e}^{\frac{EA}{JPN}}-\varsigma\Delta\hat{e}^{\frac{EA}{JPN}}$$

$$B^p_1(t) = \frac{-1}{D}\left\{\begin{bmatrix}\eta + \psi(\theta+\delta+\rho\lambda(1+\sigma)) \\ +(1+\psi\rho)(b_1+b_2b_3-b_3)\end{bmatrix}\right\}\{1-\psi(\delta+\theta)-\eta\}^t$$

$$B^p_2(t) = \frac{-1}{D}\left\{\begin{bmatrix}-\eta + \psi(-\delta-\rho\lambda(1+\sigma)) \\ +(1+\psi\rho)(b'_1+b_2b'_3-b'_3)\end{bmatrix}\right\}\{1-\psi(\delta+\theta)-\eta\}^t$$

$$B^p_3(t)\hat{z}_t = \frac{-1}{D}\left\{-(\psi\tau-\chi)\Delta\hat{e}^{\frac{EA}{US}}_t - \psi\varsigma\Delta\hat{e}^{\frac{EA}{JPN}}_t\right\}[1-\{1-\psi(\delta+\theta)-\eta\}^t]$$

C. Basket-Peg Regime without Capital Controls (C)

Similar to Appendix 2.B., substituting Equation (13) into Equation (3), we obtain the following equation such that

$$y_t - \bar{y}'_C = \frac{-(\delta+\theta)}{D}\begin{bmatrix}\bar{G}'\hat{e}_t^{US/JPN} + (1+\psi\rho)\left(\hat{p}_{t+1}^e - \hat{p}_t^e\right)\\ -(\psi\tau-\chi)\,\Delta\hat{e}_t^{EA/US} - \psi\varsigma\Delta\hat{e}_t^{EA/JPN}\end{bmatrix}$$
$$\times\left[1-\{1-\psi(\delta+\theta)-\eta\}^t\right] + \{-\delta(1-\upsilon)+\theta\upsilon$$
$$-\rho(1+\sigma)(1-\upsilon)\}\hat{e}_t^{US/JPN} + \rho\left(\hat{p}_{t+1}^e - \hat{p}_t^e\right) - \tau\Delta\hat{e}_t^{EA/US}$$
$$-\varsigma\Delta\hat{e}_t^{EA/JPN} \tag{A7}$$

where $\bar{G}' = [\psi\{\theta\upsilon - \delta(1-\upsilon) - \rho(1+\sigma)(1-\upsilon)\} - \eta(1-\upsilon)]$.

We take the expectation for both sides of Equation (13) and solve for $\hat{p}_{t+1}^e$:

$$\hat{p}_{t+1}^e = (c_1\upsilon + c_1')\hat{e}_t^{US/JPN} + c_2\hat{p}_t^e \tag{A8}$$

Then, we substitute for $\hat{p}_{t+1}^e$ in Equation (13) and obtain an expression for $\hat{p}_t^e$ such that

$$\hat{p}_t^e = (c_3\upsilon + c_3')\hat{e}_t^{US/JPN} \tag{A9}$$

Substituting Equations (A8) and (A9) into Equations (A7) and (13), respectively, we obtain

$$y_t - \bar{y}'_C = C_1(t)\upsilon\hat{e}_t^{US/JPN} + C_2(t)\hat{e}_t^{US/JPN} + C_3(t)\hat{z}_t \tag{18}$$

$$p_t - \bar{p}'_C = C_1^p(t)\upsilon\hat{e}_t^{US/JPN} + C_2^p(t)\hat{e}_t^{US/JPN} + C_3^p(t)\hat{z}_t \tag{18a}$$

where

$$C_1(t) = \frac{-(\delta+\theta)}{D}\left\{\begin{bmatrix}\eta+\psi(\rho\sigma+\rho+\theta+\delta)\\ +(1+\psi\rho)(c_1+c_2c_3-c_3)\end{bmatrix}\right\}[1-\{1-\psi(\delta+\theta)-\eta\}^t]$$
$$+(\delta+\theta)+\rho(1+\sigma)+\rho(c_1+c_2c_3-c_3)$$

$$C_2(t) = \frac{-(\delta+\theta)}{D}\left\{\begin{bmatrix}-\eta-\psi(\rho\sigma+\rho+\delta)\\ +(1+\psi\rho)(c_1'+c_2c_3'-c_3')\end{bmatrix}\right\}[1-\{1-\psi(\delta+\theta)-\eta\}^t]$$
$$-\theta-\rho(1+\sigma)\theta+\rho(c_1'+c_2c_3'-c_3')$$

$$C_3(t)\hat{z}_t = \frac{(\delta+\theta)}{D}\left\{\begin{matrix}(\psi\tau-\chi)\Delta\hat{e}_t^{\frac{EA}{US}}\\ +\psi\varsigma\Delta\hat{e}_t^{\frac{EA}{JPN}}\end{matrix}\right\}[1-\{1-\psi(\delta+\theta)-\eta\}^t] - \tau\Delta\hat{e}_t^{\frac{EA}{US}} - \varsigma\Delta\hat{e}_t^{\frac{EA}{JPN}}$$

$$C_1^p(t) = \frac{-1}{D}\left\{\begin{bmatrix}\eta+\psi(\theta+\delta+\rho(1+\sigma))\\ +(1+\psi\rho)(c_1+c_2c_3-c_3)\end{bmatrix}\right\}\{1-\psi(\delta+\theta)-\eta\}^t$$

$$C_2^p(t) = \frac{-1}{D}\left\{\begin{bmatrix} -\eta - \psi(\delta + \rho(1+\sigma)) \\ +(1+\psi\rho)(c_1' + c_2 c_3' - c_3') \end{bmatrix}\right\}\{1 - \psi(\delta+\theta) - \eta\}^t$$

$$C_3^p(t)\hat{z}_t = \frac{(\delta+\theta)}{D}\left\{(\psi\tau - \chi)\Delta\hat{e}_t^{\frac{EA}{US}} + \psi\varsigma\Delta\hat{e}_t^{\frac{EA}{JPN}}\right\}\{1 - \psi(\delta+\theta) - \eta\}^t$$

D. Floating Regime without Capital Controls (D)

New equilibrium value after the dollar–yen rate change is

$$\bar{p}_D' = \frac{f_3 + \psi\rho f_1}{E(\varepsilon+\phi\rho)}m_t + \frac{\phi\theta f_3 + \psi\theta\varepsilon f_1}{E(\varepsilon+\phi\rho)}\hat{e}_t^{EA/JPN} + g_1\left(\hat{p}_{t+1}^e - \hat{p}_t^e\right) + g_2\Delta\hat{e}_t^{EA/US} + g_3\Delta\hat{e}_t^{EA/JPN} \quad (23)$$

$$\bar{e}_D^{'EA/US} = -\frac{f_4 + \psi\rho f_2}{E(\varepsilon+\phi\rho)}m_t - \frac{\phi\theta f_4 + \psi\theta\varepsilon f_2}{E(\varepsilon+\phi\rho)}\hat{e}_t^{EA/JPN} + g_1'\left(\hat{p}_{t+1}^e - \hat{p}_t^e\right) + g_2'\Delta\hat{e}_t^{EA/US} + g_3'\Delta\hat{e}_t^{EA/JPN} \quad (24)$$

where

$$g_1 = \frac{\phi\rho f_3 + \left(1 + \psi\rho\left(1 + \frac{\phi\rho}{\varepsilon+\phi\rho}\right)\right)f_1}{E(\varepsilon+\phi\rho)}, g_2 = \frac{-\phi\tau f_3 + \left(\chi - \psi\tau\left(1 + \frac{\phi\rho}{\varepsilon+\phi\rho}\right)\right)f_1}{E(\varepsilon+\phi\rho)},$$

$$g_3 = \frac{\phi\varsigma f_3 - \left(\psi\varsigma\left(1 + \frac{\phi\rho}{\varepsilon+\phi\rho}\right)\right)f_1}{E(\varepsilon+\phi\rho)}, g_1' = -\frac{\phi\rho f_4 + \left(1 + \psi\rho\left(1 + \frac{\phi\rho}{\varepsilon+\phi\rho}\right)\right)f_2}{E(\varepsilon+\phi\rho)},$$

$$g_2' = \frac{-\phi\tau f_4 + \left(\chi - \psi\tau\left(1 + \frac{\phi\rho}{\varepsilon+\phi\rho}\right)\right)f_2}{E(\varepsilon+\phi\rho)}, g_3' = \frac{-\phi\varsigma f_4 - \left(\psi\varsigma\left(1 + \frac{\phi\rho}{\varepsilon+\phi\rho}\right)\right)f_2}{E(\varepsilon+\phi\rho)}$$

Substituting Equations (23) and (24) into Equation (3), we obtain the following equation such that

$$y_t - \bar{y}_D' = H\bar{p}' + (\delta+\theta)h_1\bar{e}_D^{'EA/US} + \frac{\rho}{\varepsilon+\phi\rho}m_t + \theta h_2\hat{e}_t^{EA/JPN} + \rho h_2\left(\hat{p}_{t+1}^e - \hat{p}_t^e\right) - \tau h_2\Delta\hat{e}_t^{EA/US} - \varsigma h_2\Delta\hat{e}_t^{EA/JPN} \quad (A10)$$

where $H = \left[-(\delta+\theta)\left(1-\omega_2^t\right) + \frac{1+\phi(\delta+\theta)}{\varepsilon+\phi\rho} - (\delta+\theta)h_1\kappa\omega_2^t\right]$, $h_1 = 1 - \frac{\phi\rho}{\varepsilon+\phi\rho}$, and $h_2 = 1 + \frac{\phi\rho}{\varepsilon+\phi\rho}$.

We take the expectation for both sides of Equation (20) and solve for $\hat{p}^e_{t+1}$:

$$\hat{p}^e_{t+1} = d_1 \hat{e}^{US/JPN}_t + d_2 \hat{p}^e_t \tag{A11}$$

Then, we substitute for $\hat{p}^e_{t+1}$ in Equation (20) and obtain an expression for $\hat{p}^e_t$ such that

$$\hat{p}^e_t = d_3 \hat{e}^{US/JPN}_t \tag{A12}$$

Substituting Equations (A11) and (A12) into Equations (A10) and (20), respectively, we obtain

$$y_t - \bar{y}'_D = D_1(t)\hat{e}^{US/JPN}_t + D_2(t)\hat{z}_t + D_3(t)m_t \tag{25}$$

$$p_t - \bar{p}'_D = D^p_1(t)\hat{e}^{US/JPN}_t + D^p_2(t)\hat{z}_t + D^p_3(t)m_t \tag{25a}$$

where

$$D_1(t) = H\frac{\phi\theta f_3 + \psi\varepsilon\theta f_1}{E(\varepsilon + \phi\rho)} - (\delta + \theta)\frac{\phi\theta f_4 + \psi\varepsilon\theta f_2}{E(\varepsilon + \phi\rho)}h_1$$
$$+ [Hg_1 + h_1 g'_1(\delta + \theta) + \rho h_2](d_1 + d_2 d_3 - d_3) + h_2\theta$$
$$D_2(t)\hat{z}_t = \left\{Hg_2 + h_1 g'_2(\delta + \theta) - \tau h_2\right\}\Delta\hat{e}^{EA/US}_t$$
$$+ \left\{Hg_3 + h_1 g'_3(\delta + \theta) - \varsigma h_2\right\}\Delta\hat{e}^{EA/JPN}_t,$$
$$D_3(t) = H\frac{f_3 + \psi\rho f_1}{E(\varepsilon + \phi\rho)} - (\delta + \theta)h_1\frac{f_4 + \psi\rho f_2}{E(\varepsilon + \phi\rho)} + \frac{\rho}{\varepsilon + \phi\rho},$$
$$D^p_1(t) = -\omega^t_2\left[\frac{\phi\theta f_3 + \psi\theta\varepsilon f_1}{E(\varepsilon + \phi\rho)} + g_1(d_1 + d_2 d_3 - d_3)\right],$$
$$D^p_2(t) = -\omega^t_2\left[g_2\Delta\hat{e}^{EA/US}_t + g_3\Delta\hat{e}^{EA/JPN}_t\right], \text{ and } D^p_3(t) = -\omega^t_2\left(\frac{f_3 + \psi\rho f_1}{E(\varepsilon + \phi\rho)}\right).$$

Appendix 3. Saddle Path Stability under a Floating Regime

Characteristic roots of difference Equations (19) and (20) can be derived by solving the equation below:

$$\omega^2 - (2 + f_1 + f_4)\omega + (1 + f_1 + f_4 + E) = 0 \tag{A13}$$

Solving this equation,

$$\omega_1, \omega_2 = \frac{1}{2}(2 + f_1 + f_4) \pm \sqrt{(2 + f_1 + f_4)^2 - 4(1 + f_1 + f_4 + E)} \tag{A14}$$

Now we assume some assumptions to satisfy saddle path stability, such as

(a) $(2 + f_1 + f_4)^2 - 4(1 + f_1 + f_4 + E) > 0$,

(b) $1 + f_1 + f_4 + E > 0$, and

(c) $2 + f_1 + f_4 - \sqrt{(2 + f_1 + f_4)^2 - 4(1 + f_1 + f_4 + E)} < 2$

First, under (a), both ω_1, ω_2 are real and distinct. It is found that $\omega_1 > 1$. Now under (b),

$$\omega_1\omega_2 = 1 + f_1 + f_4 + E > 0$$

Therefore, $\omega_2 > 0$. Lastly, (c) implies that $\omega_2 < 1$. The system is described by the unique stable saddle path. We can express the solution for the original variables as

$$e_D^{EA/US} - \bar{e}_D^{\prime EA/US} = \kappa(p_0 - \bar{p}_D')\omega_2^t \tag{A15}$$

$$p_t - \bar{p}_D' = (p_0 - \bar{p}_D')\omega_2^t \tag{A16}$$

From these equations above, the saddle path is

$$e_D^{EA/US} - \bar{e}_D^{\prime EA/US} = \kappa(p_t - \bar{p}_D') \tag{A17}$$

where $\kappa = \frac{\omega_2 - 1 - f_4}{f_3}$.

Appendix 4. Price Level Stability

In the case of the price level stability, the cumulative loss can be shown as

$$L^p(T_1, T_2) = \sum_{t=1}^{T_0+T_1+T_2} \beta^{t-1}(p_t - \bar{p}')^2 \tag{27a}$$

A. Maintaining a Dollar-Peg Regime (1)

The cumulative loss evaluated in terms of deviation of the price level from the steady state for maintaining a dollar-peg regime is shown as follows:

$$L_1^p(i^*, T_1 + T_2) = \sum_{t=1}^{T_0} \beta^{t-1}(p_t - \bar{p}'_A)^2 + \sum_{t=T_0+1}^{T_0+T_1+T_2} \beta^{t-1}(p_t - \bar{\bar{p}}'_A)^2 \tag{28a}$$

$$i_p^* = argmin \sum_{t=T_0}^{T_0+T_1+T_2} \beta^{t-1}(p_t - \bar{p}'_A)^2 \tag{28a'}$$

where $(p_t - \bar{p}'_A) = A_1^p(t)\hat{e}_t^{US/JPN} + A_2^p(t)\Delta\hat{e}_t^{EA/JPN} + A_3^p(t)i_p^*$.

B. Gradual Adjustment to a Basket Peg without Capital Controls (2)

The cumulative loss for a gradual shift to a basket peg without capital controls is defined as follows:

$$L_2^p(\upsilon_p^*, T_1 + T_2) = \sum_{t=1}^{T_0} \beta^{t-1}(p_t - \bar{p}'_A)^2 + \sum_{t=T_0+1}^{T_0+T_1} \beta^{t-1}(p_t - \bar{p}'_B)^2 + \sum_{t=T_0+T_1+1}^{T_0+T_1+T_2} \beta^{t-1}(p_t - \bar{p}'_C)^2 \tag{29a}$$

where $(p_t - \bar{p}'_A) = A_1^p(t)\hat{e}_t^{US/JPN} + A_2^p(t)\Delta\hat{e}_t^{EA/JPN} + A_3^p(t)i_p^*$ and υ_p^* is an optimal basket weight for the transition policy of stabilizing the price level.

C. Sudden Shift to a Basket Peg without Capital Controls (3)

The cumulative loss for a sudden shift to a basket peg without capital controls is shown as follows:

$$L_3^p\left(\upsilon_p^{**}, T_1 + T_2, \tilde{e}_t^{EA/US,2}\right) = \sum_{t=1}^{T_0} \beta^{t-1}(p_t - \bar{p}'_A)^2 + \sum_{t=T_0+1}^{T_0+T_1+T_2} \beta^{t-1}(p_t - \bar{p}'_C)^2 \tag{30a}$$

where $(p_t - \bar{p}'_A) = A_1^p(t)\hat{e}_t^{US/JPN} + A_2^p(t)\Delta\hat{e}_t^{EA/JPN} + A_3^p(t)i_p^*$ and υ_p^{**} is an optimal weight for stabilizing the price level.

D. Sudden Shift from a Dollar-Peg to a Floating Regime (4)

The cumulative loss for a sudden shift from a dollar-peg to a floating regime is defined as follows:

$$L_4^p\left(m_p^*, T_1+T_2, \tilde{e}_t^{EA/US,2}\right) = \sum_{t=1}^{T_0} \beta^{t-1}(p_t - \bar{p}'_A)^2 + \sum_{t=T_0+1}^{T_0+T_1+T_2} \beta^{t-1}(p_t - \bar{p}'_D)^2 \quad (31a)$$

where $(p_t - \bar{p}'_A) = A_1^p(t)\hat{e}_t^{US/JPN} + A_2^p(t)\Delta\hat{e}_t^{EA/JPN} + A_3^p(t)i_p^*$ and m_p^* is an optimal money supply for stabilizing the price level.

E. Sudden Shift from a Dollar-Peg to a Managed-Floating Regime (5)

The cumulative loss for a sudden shift from a dollar-peg to a floating regime is defined as follows:

$$\begin{aligned} &L_5^p\left(m_p^{**}, T_1+T_2, T_D, T_E, \tilde{e}_{t,E}^{EA/JPN,2}\right) \\ &= \sum_{t=1}^{T_0} \beta^{t-1}(p_t - \bar{p}'_A)^2 + \sum_{t=T_0+1}^{T_0+T_D} \beta^{t-1}(p_t - \bar{p}'_D)^2 + \sum_{t=T_0+T_D+1}^{T_0+T_D+T_E} \beta^{t-1}(p_t - \bar{p}'_E)^2 \\ &\quad + \sum_{t=T_0+T_D+T_E+1}^{T_0+T_1+T_2} \beta^{t-1}(p_t - \bar{p}'_D)^2 \end{aligned} \quad (32a)$$

where $(p_t - \bar{p}'_A) = A_1^p(t)\hat{e}_t^{US/JPN} + A_2^p(t)\Delta\hat{e}_t^{EA/JPN} + A_3^p(t)i_p^*$ and m_p^{**} is the optimal money supply for stabilizing the price level.

F. Comparison of Transition Policies

Similar to the case of output stability, we express implications from the static analysis by using a one-period loss in terms of the deviation of the price level from the steady state as follows:

$$(p_t - \bar{\bar{p}}'_A) > (p_t - \bar{p}'_C) \quad (33a)$$

$$(p_t - \bar{\bar{p}}'_A) > (p_t - \bar{p}'_D) \quad (33'a)$$

We first compare maintaining a dollar peg, policy (1), with a sudden shift to a basket-peg regime without capital controls, policy (3). We define a threshold time

period T_C^{*p} such that

$$L_1^p\left(i_p^*, T_C^{*p}\right) = L_3^p\left(\upsilon_p^{**}, T_C^{*p}, \tilde{e}_t^{EA/US,2}\right)$$

For the price level stability, similar statements will be satisfied:

$$L_1^p(i_p^*, t) < L_3^p\left(\upsilon_p^{**}, t, \tilde{e}_t^{EA/US,2}\right) \quad \textit{if } t < T_C^{*p} \tag{34a}$$

$$L_1^p(i_p^*, t) > L_3^p\left(\upsilon_p^{**}, t, \tilde{e}_t^{EA/US,2}\right) \quad \textit{if } t > T_C^{*p} \tag{34′a}$$

Next, we compare the loss under maintaining a dollar peg, policy (1), to shifting to a floating regime, policy (4). We define a threshold period T_D^{*p} such that

$$L_1^p\left(i_p^*, T_D^{*p}\right) = L_4^p\left(m_p^*, T_D^{*p}, \tilde{e}_t^{EA/US,2}\right)$$

For the case of price level stability, similar statements will be satisfied:

$$L_1^p(i_p^*, t) < L_4^p\left(m_p^*, t, \tilde{e}_t^{EA/US,2}\right) \quad \textit{if } t < T_D^{*p} \tag{34a}$$

$$L_1^p(i_p^*, t) > L_4^p\left(m_p^*, t, \tilde{e}_t^{EA/US,2}\right) \quad \textit{if } t > T_D^{*p} \tag{34′a}$$

Summarizing the results above, maintaining a dollar-peg regime is desirable only in the short run (i.e., $t < min[T_C^{*p}, T_D^{*p}]$).

We compare a gradual adjustment to a basket peg, policy (2), with a sudden shift to a basket peg, policy (3). Given time period T_2, we define T_1^* such that

$$L_2^p(\upsilon_p^*, T_1^*, T_2) = L_3^p\left(\upsilon_p^{**}, T_1^* + T_2, \tilde{e}_t^{EA/US,2}\right)$$

For the case of price level stability, similar statements will hold as follows:

$$L_2^p(\upsilon_p^*, T_1, T_2) < L_3^p\left(\upsilon_p^{**}, T_1 + T_2, \tilde{e}_t^{EA/US,2}\right) \quad \textit{if } T_1 < T_1^* \tag{36a}$$

$$L_2^p(\upsilon_p^*, T_1, T_2) > L_3^p\left(\upsilon_p^{**}, T_1 + T_2, \tilde{e}_t^{EA/US,2}\right) \quad \textit{if } T_1 > T_1^* \tag{36′a}$$

Next, we consider a comparison between sudden shifts; that is, policy (3) and policy (4). Given time periods T_1 and T_2, the optimal basket weight υ^{**}, and money supply m^*, we define $\tilde{e}_{t,p}^{EA/US,2^*}$ such that

$$L_3\left(\upsilon_p^{**}, T_1 + T_2, \tilde{e}_{t,p}^{EA/US,2^*}\right) = L_4\left(m_p^*, T_1 + T_2, \tilde{e}_{t,p}^{EA/US,2^*}\right)$$

We obtain the similar statements as in the case of output stability:

$$L_3\left(\upsilon_p^{**}, T_1+T_2, \tilde{e}_{t,p}^{EA/US,2}\right) < L_4\left(m_p^{*}, T_1+T_2, \tilde{e}_{t,p}^{EA/US,2}\right) \quad if\ \tilde{e}_{t,p}^{EA/US,2} > \tilde{e}_{t,p}^{EA/US,2^{*}} \tag{37a}$$

$$L_3\left(\upsilon_p^{**}, T_1+T_2, \tilde{e}_{t,p}^{EA/US,2}\right) > L_4\left(m_p^{*}, T_1+T_2, \tilde{e}_{t,p}^{EA/US,2}\right) \quad if\ \tilde{e}_{t,p}^{EA/US,2} < \tilde{e}_{t,p}^{EA/US,2^{*}} \tag{37′a}$$

Finally, we contrast a shift to a managed-floating regime, policy (5), with a shift to a free-floating regime, policy (4). Given time period $T_1 + T_2$, T_D, T_E, money supply m^* and m^{**}, and exchange rate volatility for the whole period $\tilde{e}_t^{EA/US,2}$, we define the exchange rate volatility for intervention periods $\tilde{e}_{t,E,p}^{EA/US,2^{**}}$:

$$L_5\left(m_p^{**}, T_1+T_2, T_D, T_E, \tilde{e}_{t,E,p}^{EA/US,2^{**}}\right) = L_4\left(m_p^{*}, T_1+T_2, \tilde{e}_{t,p}^{EA/US,2^{**}}\right)$$

We obtain similar statements to the case of output stability.

$$L_5\left(m_p^{**}, T_1+T_2, T_D, T_E, \tilde{e}_{t,E,p}^{EA/US,2}\right) < L_4\left(m_p^{*}, T_1+T_2, \tilde{e}_{t,p}^{EA/US,2}\right) \quad if\ \tilde{e}_{t,E}^{EA/US,2} > \tilde{e}_{t,E}^{EA/US,2^{**}} \tag{38a}$$

$$L_5\left(m_p^{**}, T_1+T_2, T_D, T_E, \tilde{e}_{t,E,p}^{EA/US,2}\right) > L_4\left(m_p^{*}, T_1+T_2, \tilde{e}_{t,p}^{EA/US,2}\right) \quad if\ \tilde{e}_{t,E}^{EA/US,2} < \tilde{e}_{t,E}^{EA/US,2^{**}} \tag{38′a}$$

Appendix 5. Comparison of Transition Policies

Table A.5. **Cost Estimates of the Five Transition Policies**

Policy	Costs	Estimates	
		PRC	Thailand
(1) Maintaining a dollar-peg regime	Limited capital inflows	0.033[a]	0.003[a]
(2) Gradually shifting to a basket-peg regime	Time to reach stable regime	0.003[b]	0.000096[b]
	Adjustment costs	0.0066[c]	0.00000079[c]
(3) Suddenly shifting to a basket-peg regime	High volatility of i	0.0028[d]	0.00000037[d]
	High volatility of $e^{EA/US}$ and $e^{EA/JPN}$	0.0030[e]	0.00018[e]
(4) Suddenly shifting to a free-floating regime	High volatility of i	0.0034[d]	0.0000038[d]
	High volatility of $e^{EA/US}$ and $e^{EA/JPN}$	0.034[e]	0.0050[e]
	Large deviations of $e^{EA/US,e}$ and $e^{EA/JPN,e}$	0.0013[f]	0.000024[f]

Continued.

Table A.5. *Continued.*

Policy	Costs	Estimates PRC	Estimates Thailand
(5) Suddenly shifting to a managed-floating regime	High volatility of i	0.0034[d]	0.0000038[d]
	No monetary policy autonomy during interventions	0.023[g]	0.00038[g]

PRC = People's Republic of China.
Notes:
[a]The estimate is the cumulative losses over 9 quarters (one initial period plus 2 years).
[b]The estimate is the difference between the cumulative losses under a transition period of 14 quarters and one of 18 quarters.
[c]The estimate is the difference between the cumulative losses based on baseline λ and on a 20% deviation from the baseline λ.
[d]The estimate is the change in cumulative losses due to an increase in interest rates originally driven by a 0.001-unit deviation $e^{US/JPN}$ shock.
[e]The estimate is a change in cumulative losses due to a 0.001-unit $e^{US/JPN}$ shock.
[f]The estimate is a change in cumulative losses due to a 0.001-unit $e^{US/JPN,e}$ shock.
[g]The estimate is a fraction of cumulative losses during intervention periods.
Source: Authors' calculations.

Appendix 6. Sources of Data, Unit Root, and Cointegration Tests

Appendix 6 summarizes sources of data for our regressions and the results of the unit root and cointegration tests. Table A6.1 provides details on our data and sources.

Table A6.1. **Source of Data for Estimation**

Variables	Definition	Economy	Source
$e_t^{EA/US}$	Nominal US dollar exchange rate	PRC, THA	IMF IFS
$e_t^{EA/JPN}$	Nominal yen exchange rate	PRC, THA	IMF IFS
$e_t^{EA/US} + p_t^{US} - p_t$	Real US dollar exchange rate	PRC, THA	IMF IFS
$e_t^{EA/JPN} + p_t^{JPN} - p_t$	Real yen exchange rate	PRC, THA	IMF IFS
$e_t^{US/JPN}$	Nominal dollar–yen exchange rate	JPN	IMF IFS
i_t	Nominal government bond yields	PRC, THA	IMF IFS
$i_t - (p_{t+1}^e - p_t^e)$	Real government bond yields	PRC, THA	IMF IFS
i_t^{US}	Nominal US government bond yields	US	IMF IFS
$m_t - p_t$	Real money supply (M1)	PRC, THA	IMF IFS
$\Delta e_t^{EA/US}$	Risk premium on US dollar exchange rate	PRC, THA	IMF IFS
$\Delta e_t^{EA/JPN}$	Risk premium on yen exchange rate	PRC, THA	IMF IFS
$p_{t+1} - p_t$	Change in domestic CPI	PRC, THA	IMF IFS
$y_t - \bar{y}$	Output gap	PRC, THA	Authors' calculation

CPI = Consumer Price Index, IMF IFS = International Monetary Fund's *International Financial Statistics*, JPN = Japan, PRC = People's Republic of China, THA = Thailand, US = United States.

We start by applying the DF-GLS unit root tests. The results of the unit root test are presented in Table A6.2. Reflecting the 10% significance critical value on DF-GLS statistics, some variables, such as the real interest rate and the output

Table A6.2. **Dicky-Fuller Generalized Least Square Unit Root Tests**

A. People's Republic of China

Variables	Degree	Trend	Lag	DF-GLS Stat.[a]	Results
$e^{EA/US}$	Level	0	0	-2.67^{***}	$I(0)^{b}$
$e^{EA/JPN}$	Level	0	1	-3.06^{***}	$I(0)^{b}$
i	Level	0	0	-1.65^{*}	$I(0)^{b}$
$i-(p^{e}_{t+1}-p_t)$	Level	0	8	0.17	
	1st diff.	0	7	-5.32^{***}	$I(1)^{c}$
i^{US}	Level	0	3	-2.68^{***}	$I(0)^{b}$
$m-p$	Level	0	5	-1.88^{*}	$I(0)^{b}$
$e^{EA/US}-p^{US}-p$	Level	0	0	-2.57^{**}	$I(0)^{b}$
$e^{EA/JPN}-p^{JPN}-p$	Level	0	2	-3.22^{***}	$I(0)^{b}$
$e^{US/JPN}$	Level	0	0	-2.80^{***}	$I(0)^{b}$
$\Delta e^{EA/US}$	Level	0	0	-3.31^{***}	$I(0)^{b}$
$\Delta e^{EA/JPN}$	Level	0	0	0.17	
	1st diff.	0	0	-0.684^{***}	$I(1)^{c}$
$p_{t+1}-p_t$	Level	0	8	0.14	
	1st diff.	0	3	-4.95^{***}	$I(1)^{c}$
$y_t-\bar{y}$	Level	0	4	-1.61^{*}	$I(0)^{b}$

B. Thailand

Variables	Degree	Trend	Lag	DF-GLS Stat.[a]	Results
$e^{EA/US}$	Level	0	0	-2.90^{***}	$I(0)^{b}$
$e^{EA/JPN}$	Level	0	0	-3.27^{***}	$I(0)^{b}$
i	Level	0	0	-5.24^{***}	$I(0)^{b}$
$i-(p^{e}_{t+1}-p_t)$	Level	0	0	-1.07	
	1st diff.	0	0	-5.60^{***}	$I(1)^{c}$
i^{US}	Level	0	0	-0.97	
	1st diff.	0	0	-4.04^{***}	$I(1)^{c}$
$m-p$	Level	0	2	-2.77^{***}	$I(0)^{b}$
$e^{EA/US}-p^{US}-p$	Level	0	0	-3.03^{***}	$I(0)^{b}$
$e^{EA/JPN}-p^{JPN}-p$	Level	0	0	-2.21^{**}	$I(0)^{b}$
$e^{US/JPN}$	Level	0	0	-2.20^{**}	$I(0)^{b}$
$\Delta e^{EA/US}$	Level	0	0	-3.81^{***}	$I(0)^{b}$
$\Delta e^{EA/JPN}$	Level	0	0	-5.81^{***}	$I(0)^{b}$
$p_{t+1}-p_t$	Level	0	0	-3.23^{***}	$I(0)^{b}$
$y_t-\bar{y}$	Level	0	2	-0.97	
	1st diff.	0	3	-1.83^{*}	$I(1)^{c}$

DF-GLS = Dicky-Fuller generalized least squares.

Notes:

[a]The critical values for the DF-GLS statistics are 5%, –1.98; and 10%, –0.62. Our results of the unit root are based on a 10% critical value.

[b]I(0) shows that the variable follows the stationary process at the level.

[c]I(1) shows that the variable has a unit root of degree 1.

Source: Authors' calculations.

gap, have a unit root. Then, we move onto Johansen cointegration tests for equations shown in Table A6.3. Using the 5% significance critical criteria, we find cointegration relationships among the variables in these equations for both the PRC and Thailand.

Table A6.3. **Johansen Cointegration Tests**

A. People's Republic of China

Equation	Variables	Trend	Hypothesis	Trace Statistics[a]	P-values[b]
Aggregate demand	$y_t - \bar{y}$	Deterministic	None[c]	162.3***	0.00
	$e^{EA/US} - p^{US} - p$		At most 1[c]	118.9***	0.00
	$e^{EA/JPN} - p^{JPN} - p$		At most 2[c]	75.8***	0.00
	$i - (p^e_{t+1} - p_t)$		At most 3[c]	36.9***	0.00
	$\Delta e^{EA/US}$		At most 4[c]	14.0*	0.08
	$\Delta e^{EA/JPN}$		At most 5[c]	2.7*	0.09
Aggregate supply	$p_{t+1} - p_t$	Deterministic	None[c]	171.3***	0.00
	$y_t - \bar{y}$		At most 1[c]	121.8***	0.00
	$e^{EA/US} - p^{US} - p$		At most 2[c]	78.8***	0.00
	$e^{EA/JPN} - p^{JPN} - p$		At most 3[c]	37.8***	0.00
	$\Delta e^{EA/US}$		At most 4[c]	14.8*	0.04
	$\Delta e^{EA/JPN}$		At most 5[c]	2.7*	0.09

B. Thailand

Equation	Variables	Trend	Hypothesis	Trace Statistics[a]	P-values[b]
Aggregate demand	$y_t - \bar{y}$	Deterministic	None[c]	162.3***	0.00
	$e^{EA/US} - p^{US} - p$		At most 1[c]	118.9***	0.00
	$e^{EA/JPN} - p^{JPN} - p$		At most 2[c]	75.8***	0.00
	$i - (p^e_{t+1} - p_t)$		At most 3[c]	36.9***	0.00
	$\Delta e^{EA/US}$		At most 4[c]	14.0*	0.08
	$\Delta e^{EA/JPN}$		At most 5[c]	2.7*	0.09

Notes:
[a]Denotes 5% critical values.
[b]Denotes MacKinnon, Haug, and Michelis (1999) p-values.
[c]Denotes rejection of the hypothesis at the 5% significance level.
Source: Authors' calculations.

Appendix 7. Simulation Algorithm

The procedure of simulation exercises is the following:

1. First, we set parameter values as reported in Table 5, which are obtained from regression results.

   - Time intervals are set as follows: $T_0 = 1$, $T_1 = 18$, and $T_2 = 18$.
   - For the exchange rates and exchange rate risks, we use the actual data for Q1 1999–Q4 2010 for the PRC, and Q1 1993–Q1 2006 for Thailand.

2. Second, we numerically compute the value of a one-period loss function for each exchange rate regime (A)–(E) (as specified in section IV.B.1–5).

   - We use the obtained reduced forms in Appendix 2.

- In the case of a floating regime, we use King-Watson (2002) solution algorithms for singular linear difference systems under rational expectations.

3. Third, we calculate the cumulative losses for each transition policy, (1)–(5) (as specified in Section V.A–E on the basis of initial optimal instrument values).

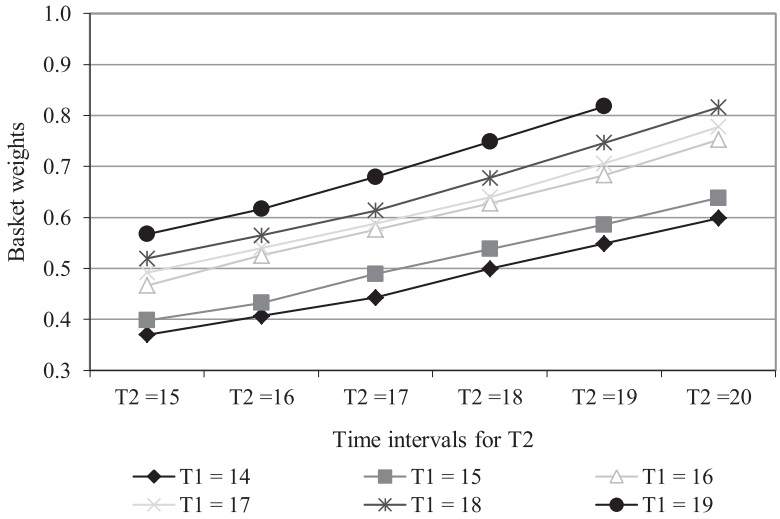
4. Fourth, we compute the optimal instrument values as specified in section V.A–E, using the cumulative losses derived in the 3rd step.

5. Fifth, on the basis of optimal instrument values obtained in the 4th step, we compute cumulative losses for each transition policy, (1)–(5).

Appendix 8. Time Intervals and Optimal Basket Weights

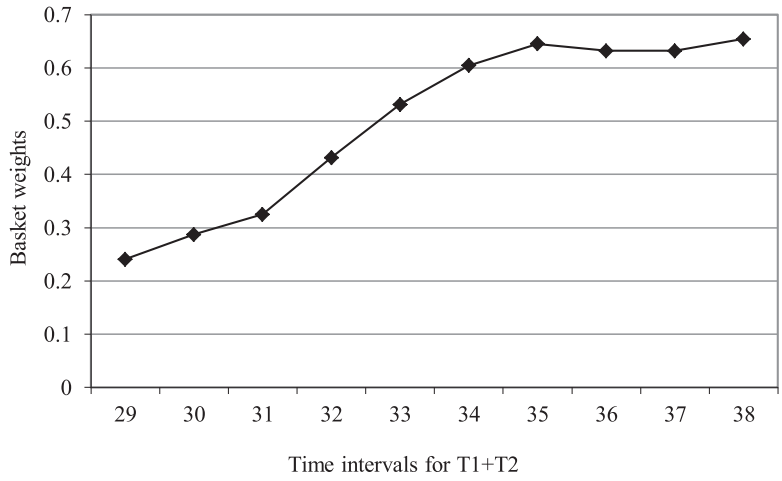
We analyze optimal basket weights under a basket peg under different time intervals using Thai data to examine the relationship between the two. First, we consider the case of a gradual adjustment to a basket-peg regime, policy (2). Given a fixed time interval for transition periods T_1 (e.g., $T_1 = 18$), the optimal basket weight increases as time intervals under the desired basket peg increase. An increase in the length of the periods under the desired basket peg leads to an increase in the share of cumulative losses under the desired basket peg (losses after the economy completes

Figure A8.1. **Optimal Basket Weights and Time Intervals under Policy (2)**



Source: Authors' calculations.

Figure A8.2. **Optimal Basket Weights and Time Intervals under Policy (3)**



Source: Authors' calculations.

a transition) in total cumulative losses. In the case of Thailand, the increase in the length of periods results in an increase in the weight on the US dollar rate. However, given a fixed time interval under the desired basket-peg T_2 (for instance $T_2 = 18$), the longer the time intervals for transition become, the higher the optimal basket weight is. An increase in the length of the transition period leads to an increase in the share of cumulative losses during transition in total cumulative losses. This results in an increase in optimal basket weights, indicating the higher relative importance of the US dollar rate for Thailand.

Next, in the case of a sudden shift to a basket-peg regime, policy (3), the longer the time intervals under the desired basket peg, the higher the optimal basket weight becomes. As in the previous case, if the time intervals under the desired basket peg become longer, the share of cumulative losses under the desired basket-peg regime in total cumulative losses increases. An increase in the time interval under the desired basket peg also results in higher optimal basket weights for Thailand.

International Trade and Risk Sharing in the Global Rice Market: The Impact of Foreign and Domestic Supply Shocks

SHIKHA JHA, KENSUKE KUBO, AND BHARAT RAMASWAMI*

In the first decade of this millennium, rising food prices returned as a concern for policy makers, especially in developing economies. This paper examines how supply shocks, both domestic and foreign, impacted imports and consumption in the world rice market between 1960 and 2010. Such an investigation is important in assessing the role of trade in compensating for domestic shocks. If shortages lead economies to impose trade restrictions, then trade may not be allowed to play an important role in stabilizing consumption. The existing literature has highlighted the importance of these policy shocks in the world rice market and how they have worked to increase the volatility of prices and trade flows. Although trade cannot be expected to play a strong role when the major producing and consuming economies are simultaneously hit by negative yield shocks, such a scenario has occurred in only about 3% of all observed cases. We also find that consumption fails to stabilize even when domestic shocks are negative and foreign shocks are positive; however, imports do peak. Thus, while trade does help in coping with domestic risks, it is unable to achieve full risk sharing. Therefore, no matter the nature of foreign shocks, the principal concern is to stabilize consumption when an economy is hit by negative domestic yield shocks. The frequency of such shocks is about 12% in all observed cases, highlighting the importance of domestic responses. We find that domestic rice stocks have been important in stabilizing consumption. The reliance on domestic policies has, in turn, kept the rice market thin.

Keywords: food prices, international trade, rice market, risk sharing, supply shocks
JEL codes: F14, Q17

I. Introduction

Early in the 21st century, an old concern resurfaced—that of rising food prices. After the food crisis in the mid-1970s, the world enjoyed declining to stable

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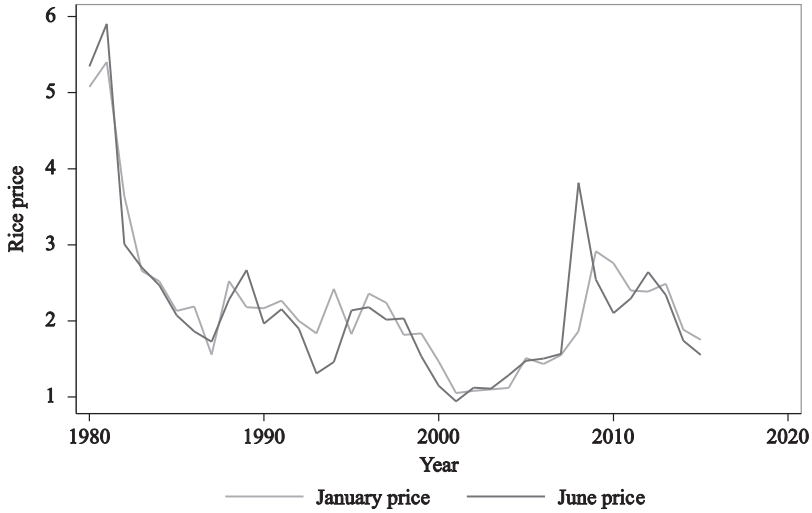
Figure 1. **World Rice Prices, 1980–2015**
($ per ton)



Notes: Monthly prices are deflated by the United States Consumer Price Index sourced from the Bureau of Labor Statistics. January prices refer to the prices prevailing in January; June prices refer to the prices prevailing in June.
Source: International Monetary Fund. Primary Commodity Prices. http://www.imf.org/external/np/res/commod/index.aspx

real prices until the mid-1990s. In 1995–1996, there was a spike in prices followed by a return to the long-term trend. From the early part of the 2000s, however, prices began creeping upward, culminating in sharp rises between 2006–2007 and 2008–2009.

Palm oil, rice, and wheat prices doubled between 1999–2000 and 2007–2008, while maize and soybean prices increased by more than 75% over the same period (Gilbert 2011).[1] What was striking was that the price spikes happened in a very short time interval. In nominal terms, world maize prices increased by 54% from August 2006 to February 2007. This was followed by an increase in world wheat prices of 125% from May 2007 to March 2008. The most dramatic increase occurred in rice prices. From April 2001 to September 2007, a gradual upward drift saw the price of Thai 100% B rice double from $170 per ton to $335 per ton, amounting to a 67% increase relative to the United States (US) Consumer Price Index. Between October 2007 and April 2008, the price tripled again to over $1,000 per ton (Dawe and Slayton 2011). These trends are evident in Figure 1, which plots rice prices deflated by the US consumer price index for the period 1980–2015.

The food price spikes of 2007–2008 renewed old debates about the efficacy and desirability of price stabilization measures. Economists have long argued that storage-based price stabilization is expensive and, in some instances, ineffective. On

[1]Gilbert (2011) reports these price changes after deflating the nominal prices by the US Producer Price Index.

the other hand, opening up the economy to trade can be effective in insulating against severe domestic shocks. The food price crisis of 2007–2008, however, planted doubts in the minds of policy makers about the reliability of world markets in times of need. Several policy studies have concluded that some public grain reserves are necessary. Price stabilization pursued through public stocks cannot be effective, however, when borders are open. Therefore, some restriction of trade is also necessary.

Within the context of this debate, the goal of this paper is to examine how supply shocks, both domestic and foreign, have impacted imports and consumption in the global rice market between 1960 and 2010. In autarkic economies, domestic supply shocks drive consumption shocks as well. In economies open to trade, and when trade functions well, domestic consumption depends on both domestic and foreign supply shocks. Compared to autarky, domestic shocks matter less because of access to world markets. For small open economies, domestic shocks should not matter at all.

These ideal outcomes may not be obtained, however, if policies impede trade. Rising prices often provoke governments to put in place policies that buffer the impacts. When these policies take the form of trade restrictions, world trade may shrink; thus, economies might not have access to world supplies to compensate for adverse domestic shocks. Rice is commonly considered the archetype of an agricultural staple that is subject to such endogenous policy shocks. Hence, we chose to study the impact of domestic and foreign supply shocks on rice imports and consumption.

The structure of this paper is as follows. The next two sections offer a selective survey of the literature on the global rice market with respect to endogenous policy shocks and the reliability of the rice trade. Section IV is a descriptive account of the global rice trade and the trade interventions of major exporters. Section V offers a statistical analysis of the impact of exogenous domestic and foreign supply shocks on imports and consumption. Section VI extends this to include the policy variable of domestic and foreign stocks. Concluding remarks comprise section VII.

II. The Rice Market and Endogenous Shocks

The role of policy responses in provoking and exaggerating price spikes has been evident in the global rice market. A review of the literature reveals that the rice market is particularly subject to endogenous policy shocks. Unlike wheat and maize, a relatively small proportion of world rice production (about 9%) is traded internationally. Moreover, the wheat and maize trade is driven by surpluses from rich and large land-abundant economies such as Argentina, Australia, Canada, and the US. In the case of wheat, Australia, Canada, and the US export more than 50% of their production. The biggest rice exporter, Thailand, exports close to 40% of its output. However, its share in world rice output is less than 5% of the total. Meanwhile, India is emerging as a strong competitor to Thailand, vying for the

position of the top exporter. Yet, in 2014–2015, despite a record increase amounting to a little over one-fifth of world production, India exported barely 10% of its output. By offloading its huge stockpile, India could become the swing actor in the world rice market.

Apart from India, other large rice-producing economies such as Bangladesh, the People's Republic of China (PRC), and Indonesia are either deficient in production, or at best, have small surpluses relative to consumption. All of these economies have poor populations that are severely affected when rice prices rise. Due to such food security concerns, these economies will likely reduce their net supply to the world market in times of crisis. This can take the form of export restrictions or reductions in import tariffs. Following a self-sufficiency approach, much of Asia is stockpiling rice as well. In either case, the attempts of these economies to increase their share of world consumption can raise world prices. Thus, policies directed toward insulating domestic markets magnify international price volatility when all economies attempt to insulate their respective domestic markets at the same time (Abbot 2011, Martin and Anderson 2011).

During the crisis of 2007–2008, many scholars argued that it was likely that the spike in rice prices was due not to crop failure or low stocks but to policy measures put in place by panicked governments. As early as October 2008, Timmer (2008) argued that the underlying causes for the rise in rice prices were different from those for wheat and maize prices. Low stocks, crop failures, and financial speculation were not plausible factors behind the price increases in rice in 2007–2008. Nor could these increases be attributed in a straightforward manner to the rise in wheat or maize prices because substitution in consumption among these grains is limited. Rather, Timmer contended, the spike must be seen as being due to export restrictions by some of the major exporting economies, which induced panic buying by importers, such as the Philippines, and a storage-driven approach because of the hoarding instincts of governments and other agents. This sentiment has been echoed by others (Dawe and Slayton 2011, Gilbert and Morgan 2010, Wright 2011).

Martin and Anderson (2011) estimate that more than 45% of the explained change in international rice prices during 2005–2008 was due to export restrictions (compared with 29% for wheat). Using a global economywide model, Jensen and Anderson (2014) estimate the impact of such price-insulating policies to be about one-third of the world price rise. If anything, these estimates are surprising in that endogenous shocks account for only one-third to one-half of the rice price increase when most of the literature seems to argue that increases are significantly driven by policy shocks. The hypothesis that export policies contribute to global price volatility has also been tested by Giordani, Rocha, and Ruta (2012). Using a dataset on trade measures relating to the food sector, they found that the probability that an economy imposes a new export restriction is positively associated with global restrictions on the product (i.e., the share of international trade covered by export restrictions). For 2008–2010, they estimate that a 1% surge in the share of trade

covered by export restrictions is associated with a 1.1% increase in international food prices.

III. The Reliability of the Rice Trade and Rice Markets

In an integrated global market, trade provides a means for price stabilization without costly investment in commodity stocks. This has been the view of many economists. However, this does not take into account the possibility of government intervention such as market-insulating policies. If exporters fearing a shortfall restrict their supply, importers are deprived of food just when they need it the most. Such an experience can persuade importers that the food trade is unreliable and that they should increase self-sufficiency by investing in domestic stocks and raising production irrespective of the costs.

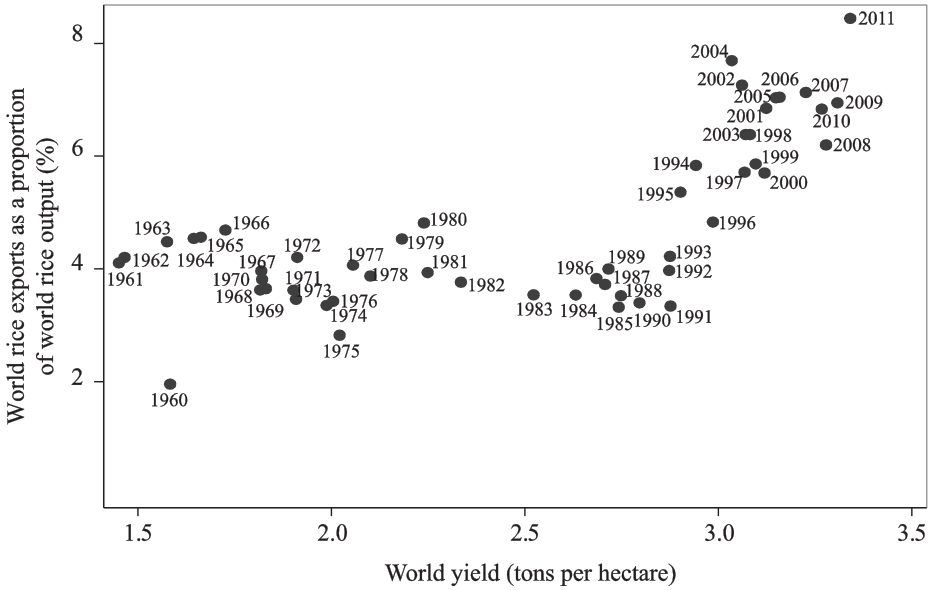
Gilbert (2011) argues that rice trade and rice markets are the most unreliable among those of the major grains. In an earlier work (Gilbert 2010), he showed that a commonly quoted world rice price—the spot price in Bangkok—follows various national prices rather than the other way around (as it is for maize). Given that the rice market "functions least well," Gilbert (2011) argues for a pragmatic approach in which it is recognized that low-income economies "can probably rely on being able to import additional maize or wheat if this proves necessary, but may justifiably be worried about being able to do so for rice." Further, he argues, "[T]his points towards the need for contingency arrangements for rice—either food security stocks, or formal trade agreements with rice exporters or, where this is feasible, a move towards rice self-sufficiency."

A related point is that the rice market has been seen to be somewhat disconnected from the markets for other cereals. Shocks to rice supply and demand are not highly correlated with those of other grains. Global futures markets are irrelevant to rice and the crop is not used as a biofuel (Dawe and Slayton 2011). It is in this sense that Gilbert and Morgan (2010) regard the rice price spike in 2007–2008 as "peculiar and in some sense pre-modern." Unlike that of other grains, the price volatility in the rice market does not always depend on the fundamentals of demand and supply shocks and price elasticities. The particular problem of the rice market is the tendency of important trading economies to shield themselves from external shocks. Hence, "rice is different" and the future course of volatility will depend on how the international community addresses the particular problems of this market (Gilbert and Morgan 2010).

IV. Global Rice Trade

Imagine a two-economy trade model in which one of the economies is producing rice. Imagine also that there is no government intervention in either

Figure 2. **World Rice Trade and World Yields**



Source: Authors' estimates.

Table 1. **World Export-to-Output Ratios**
(in percentages)

	1960–1993	**1994–2011**
Mean	3.82	7.16
Standard deviation	0.56	2.14
Coefficient of variation (%)	14.66	29.89

Source: Authors' estimates.

exports or imports. The production of rice is subject to stochastic yield shocks. It is expected that the higher the yield, the greater the volume of rice that is traded. Figure 2 plots the proportion of world output that is exported against world yields for 1960–2011. The world yield is the production share weighted average of individual economy yields. For world yields up to 3 tons per hectare (ha), world exports fluctuate at around 4% of world output without any trend. Beyond that, in the range of 3–3.5 tons per ha, the ratio of exports to world output fluctuates at a higher level of around 7%. A closer look shows that the observations in the right half of Figure 2, involving world yields of more than 3 tons per ha, belong to the period beginning in 1994.

Table 1 shows that the average export–output ratio in 1994–2011 was 7.2%—which represents an increase of 87% over the average value in the pre-1994 period. The discrete jump in the export–output ratio is primarily due to increased rice exports from India. Until the early 1990s, quantitative restrictions clamped down on

nonbasmati rice exports from India. The removal of these restrictions in 1993–1994 led to nonbasmati rice exports of 4.5 million tons from less than 1 million tons in the early 1990s (Kubo 2011). The other factor behind the higher export–output ratio in 1994–2011 is the rise of Viet Nam as a major rice exporter. This has been a more gradual process that started with the economy's reentry into the world market in 1989. Therefore, export liberalization in India and Viet Nam, which are the next leading exporters after Thailand, explains why the world rice market grew relatively thicker in the 1990s.

It could, however, be argued that a common trend may be responsible for the correlation between world yield and the export–output ratio. Indeed, if the export–output ratio is regressed on world yield and a time trend (whether linear or quadratic), the coefficient of world yield, while still significant, becomes negative. While this means that deviations from the trend are negatively correlated, the presence of a common trend is suggestive of the positive association between the two variables.

In Table 1, the pre-1994 period is characterized by low variability in the export–output ratio even as yields doubled, while the post-1994 period is characterized by high variability in the export–output ratio even as yields remained in a narrow range of 3–3.5 tons per ha. The coefficient of variation of the export–output ratio in 1994–2011 is twice that in the pre-1994 period. Thus, it seems that while world markets have been more open since the 1990s, policy interventions have made them more unstable as well.[2] It could be that limited reforms and a longer period of time allowed for developing (vis-à-vis developed) economies to meet their market access commitments generated by the Uruguay Round helped these countries stabilize domestic prices even as world prices became more volatile. Wailes (2005) reports coefficients of variation of domestic rice prices of 26% for Indonesia, 37% for the PRC, and 43% for India over the 15–20 years prior to 2005. Much of the trade expansion during that period was on account of the surging rice imports of Asian and African economies that was supported by abundant supplies in major exporting economies (Calpe 2006). However, following the food price crisis, India and Viet Nam were among the first economies to impose export restrictions in 2007 as both have domestic concerns with impacts that spill over into international markets. This was evident even prior to the 2007–2008 crisis.

In India, the principal domestic policy imperative is for the government to procure enough supplies to maintain its distribution channels of subsidized rice and wheat. A failure to restrict procurement left India with an accumulation of massive stocks in 2001 amounting to 51 million tons of grain, including 25 million tons of rice. This prompted the government to sell the grain at subsidized prices for

[2]Higher variability in the export–output ratio could also be because of greater yield instability. However, this does not appear to be the case. While mean world yields increase from 2.16 tons per ha in the first period to a little over 3 tons per ha in the second period, the coefficient of variation drops from 21% to 7.4% between the periods.

export. Global price effects were thus a byproduct of domestic food security policy in India, a large rice trader (Jha 2012). The subsequent unloading of stocks in the international market led to rising exports and the prolonged stagnation of rice prices in the global market (Kubo 2011). Such large-scale dumping of government stocks on the world market ceased after 2004. By 2005, rice stocks in India had fallen to 13 million tons and, more significantly, wheat stocks had dropped to 2 million tons. A subsequent shortfall in wheat procurement that coincided with wheat crop failures in the rest of the world panicked the Indian government into wheat imports and a determination not to allow similar shortfalls in rice procurement. So after dumping rice stocks on the world market in the early 2000s, the government moved to restrict and finally ban rice exports in the late 2000s. With the recovery of rice and wheat stocks, the government eventually lifted export restrictions.

Viet Nam has always maintained tight control over rice exports. Initially this took the form of export quotas for registered companies. These were later abolished and the government now suspends rice exports once the total reaches a targeted level. In 2007, this happened routinely. In 2008, faced with rising domestic prices, the government did not allow new export contracts until July of that year. As in India, concern over the domestic availability of rice prompted the government to tightly monitor export volumes. However, there is a difference as well: India's exports are less than 5% of its consumption; in Viet Nam, they amount to more than 30% of its consumption. Therefore, global rice sales are more important for Viet Nam's economy and government regulations have been more predictable and more sensitive to the interests of exporters.

V. The Impact of Exogenous Shocks on Imports and Consumption

A systematic relationship between world yields and the global rice trade is not evident in Figure 2. Within a two-economy model, it would be realistic to assume that both economies produce rice. In a model of free trade, the amount of rice traded depends on both domestic yield shocks and foreign shocks. For instance, it is expected that importing economies decrease imports in response to positive domestic yield shocks and increase imports when there is a positive yield shock in a foreign economy. As imports feed into consumption, we can also consider the consequences for this indicator of economic welfare. For both economies in the model, consumption is expected to be positively related to both domestic and foreign yield shocks. In the extreme and unrealistic case of perfectly integrated markets, the source of the yield shock would not matter. A weaker hypothesis is that consumption depends positively on both domestic and foreign yield shocks. We now test these hypotheses.

Our dataset on an economy's production, area, and stocks is drawn from the US Department of Agriculture. To compute exogenous shocks, we smooth the

Table 2. **Cross-Tabulation of Foreign and Domestic Yield Shocks—All Economies**

	Foreign Yield Shock			
Domestic Shock	Negative High	Mid-Range	Positive High	Total
Negative High	116	311	88	515
	2.72	7.31	2.07	12.10
Mid-Range	533	2,111	550	3,194
	12.52	49.59	12.92	75.03
Positive High	9	363	91	548
	2.21	8.53	2.14	12.87
Total	743	2,785	729	4,257
	17.45	65.42	17.12	100.00

Note: Values in the lower row represent the number of cross-tabulated observations as a proportion of all observations.
Source: Authors' estimates.

yield series using the Holt–Winters double exponential method. The deviation of the smoothed series from the observation is defined as the yield shock. This is computed for every economy. For every economy, we also compute a foreign yield shock, which is the production weighted average of the yield shocks in each of the economies constituting the rest of the world.

To examine the potential of trade, the correlation between domestic yield and foreign yield shocks is worth considering. When there are adverse shocks to both domestic and foreign yields, trade cannot be of much help. To assess the probability of such outcomes, we slice domestic and foreign yield shocks into three categories: (i) a high negative shock, when the shock is one standard deviation below the mean; (ii) a high positive shock, when the shock is one standard deviation above the mean; and (iii) a mid-range shock, when the yield deviation is within one standard deviation of the mean. This is done for every economy and for every year in the sample. The cross-tabulation of these shocks for all economies in the sample is displayed in Table 2. Table 3 contains these cross-tabulations for the major economies that make up world rice production and trade: Bangladesh, the PRC, India, Indonesia, Iran, Malaysia, Nigeria, Pakistan, the Philippines, Saudi Arabia, Thailand, Viet Nam, and the US.

The results show that in only about 3% of the cases for the entire sample and in about 1% of the cases for the major economies, low domestic yields are accompanied by low foreign yields as well. This means that except for these instances trade, in principle, should work well in the overwhelming majority of circumstances when domestic production shortfalls are offset to some extent by higher output elsewhere, and vice versa. Yet the puzzle is that the rice trade is considered unreliable relative to other grains.

Table 4 is a regression of the first difference in log of imports (as a proportion of consumption) on the dummy variables for each of the categories in the cross-tabulations of Tables 2 and 3. The regression is based on the sample of all

Table 3. **Cross-Tabulation of Foreign and Domestic Yield Shocks—Major Economies**

	Foreign Yield Shock			
Domestic Shock	Negative High	Mid-Range	Positive High	Total
Negative High	10	56	19	85
	1.48	8.30	2.81	12.59
Mid-Range	91	334	76	501
	13.48	49.48	11.26	74.22
Positive High	22	49	18	89
	3.26	7.26	2.67	13.19
Total	123	439	113	675
	18.22	65.04	16.74	100.00

Notes: Major economies comprise the following major importing and exporting economies: Bangladesh, the People's Republic of China, India, Indonesia, Iran, Malaysia, Nigeria, Pakistan, the Philippines, Saudi Arabia, Thailand, the United States, and Viet Nam. Values in the lower row represent the number of cross-tabulated observations as a proportion of all observations.
Source: Authors' estimates.

Table 4. **Imports Regression—Dependent Variable: First Difference of Log (Imports/Consumption)**

Variable	**Coefficient**	**Standard Error**	**t-value**
Dummy variable for negative domestic yield shock and negative foreign yield shock	0.398	0.131	3.03
Dummy variable for negative domestic yield shock and mid-range foreign yield shock	0.286	0.113	2.52
Dummy variable for negative domestic yield shock and positive foreign yield shock	0.636	0.141	4.51
Dummy variable for mid-range domestic yield shock and negative foreign yield shock	0.139	0.108	1.29
Dummy variable for mid-range domestic yield shock and mid-range foreign yield shock	0.182	0.102	1.78
Dummy variable for mid-range domestic yield shock and positive foreign yield shock	0.112	0.109	1.03
Dummy variable for positive domestic yield shock and negative foreign yield shock	−0.316	0.139	−2.28
Dummy variable for positive domestic yield shock and mid-range foreign yield shock	0.057	0.112	0.51
Dummy variable for positive domestic yield shock and positive foreign yield shock	(omitted)		
Constant	−0.181	0.100	−1.80

Notes:
1. The number of observations is 2,683.
2. The sample of importing economies is for 1960–2010.
3. Regression model includes economy fixed effects.
Source: Authors' estimates.

importing economies. As expected, the percentage change in imports is negative and the greatest in absolute value when the domestic shock is highly positive and the foreign shock is highly negative. This is the case when the demand for imports

is at its minimum and the world supply is also at its lowest. Unsurprisingly, the percentage change in imports is positive and maximal when the domestic shock is highly negative and when the foreign shock is highly positive. This is the opposite case when world supply and demand for imports are at their maximum. These are instances when trade works in the expected direction. More surprisingly, imports as a proportion of consumption increase even when shocks are negative at home and abroad. In this case, world supply is low but import demand is high. For example, Indonesia imported exceptionally high volumes of rice in 1997 and 1998 to mitigate the impacts of El Niño. Similarly, the food price crisis of 2007–2008 led the Philippines to import rice at exorbitant prices in a panic-buying spree. Rice is the single most important food in these two economies, comprising almost one-half of the calorie intake in each.

There is a clear pattern to the results. The percentage change in imports is less (or negative) when domestic shocks are highly positive; it is high and positive when domestic shocks are highly negative.

To see the cost of highly negative domestic shocks, consider a regression of the log change in rice consumption as a function of the dummy variables representing the combination of highly negative, mid-range and highly positive domestic and foreign yield shocks. Table 5 shows the results for the entire sample of economies, not just importers. A second specification in the table adds lagged values of the dependent variable as regressors.[3] The impact of the shocks does not vary much between the specifications in terms of the sign and significance of the coefficients.

Reading from the first specification, rice consumption declines by 9% in the scenario of highly negative domestic and foreign yield shocks.[4] In the scenario of highly negative domestic shocks and highly positive foreign yield shocks, rice consumption declines by 4.5%. The difference in outcomes between these scenarios is a measure of the value of access to world markets. However, consumption declines in all of the scenarios involving negative domestic yield shocks. Positive foreign shocks can compensate, but not fully. Earlier, we mentioned that a reliance on trade could fail in about 2% of the instances when negative shocks affect both domestic and foreign markets. But now it is apparent that rice consumption is vulnerable in all scenarios involving negative domestic shocks. Such instances occur about 12%

[3]Conventional fixed-effects estimators (e.g., within estimator) are inconsistent when lagged values of the dependent variable are used as regressors. We used the Arellano–Bond estimator which transforms the data into first differences and takes care of the correlation between the error term (first difference of the original error term) and the lagged first differences of the dependent variable by using higher-order lags of the dependent variable as instrumental variables (Arellano and Bond 1991).

[4]This is the sum of the constant term and the coefficient of the dummy variable for highly negative domestic and foreign yield shocks. All regressions have an economy-specific fixed effect. As it is additive, it nets out when considering the difference between the base and omitted category of positive domestic and foreign yield shocks and the other categories.

Table 5. **Consumption Regression, All Economies—Dependent Variable: Log of Change in Rice Consumption**

Variable	Coefficient	Standard Error	t-value	Coefficient	Standard Error	t-value
Dummy variable for negative domestic yield shock and negative foreign yield shock	−0.222	0.032	−6.94	−0.219	0.042	−5.26
Dummy variable for negative domestic yield shock and mid-range foreign yield shock	−0.186	0.027	−6.80	−0.195	0.045	−4.37
Dummy variable for negative domestic yield shock and positive foreign yield shock	−0.176	0.034	−5.10	−0.188	0.054	−3.49
Dummy variable for mid-range domestic yield shock and negative foreign yield shock	−0.107	0.026	−4.10	−0.103	0.038	−2.71
Dummy variable for mid-range domestic yield shock and mid-range foreign yield shock	−0.092	0.025	−3.74	−0.088	0.041	−2.18
Dummy variable for mid-range domestic yield shock and positive foreign yield shock	−0.107	0.026	−4.11	−0.103	0.044	−2.35
Dummy variable for positive domestic yield shock and negative foreign yield shock	−0.006	0.034	−0.19	−0.027	0.046	−0.59
Dummy variable for positive domestic yield shock and mid-range foreign yield shock	−0.025	0.027	−0.92	−0.024	0.045	−0.53
Dummy variable for positive domestic yield shock and positive foreign yield shock	(omitted)			(omitted)		
Lagged dependent variable (first order)				−0.344	0.033	−10.30
Lagged dependent variable (second order)				−0.117	0.033	−3.55
Constant	0.131	0.024	5.44	0.141	0.039	3.60

Notes:
1. The number of observations is 4,155 (3,885 for specification with lagged dependent variables).
2. The sample consists of 87 economies for 1960–2010.
3. Regression model includes economy fixed effects.
4. The specification with lagged dependent variables has been estimated with the Arellano–Bond method using second- to sixth-order lags of the dependent variable as instrumental variables.
Source: Authors' estimates.

of the time. Perhaps this is why rice markets are regarded as unreliable by policy makers.

The flip side of these results is that rice consumption increases by about 10%–13% in all scenarios involving positive domestic shocks. Most strikingly, the increase in consumption in the scenario of positive domestic and foreign yield shocks (13%) is almost the same as in the scenario of positive domestic and negative foreign yield shocks (12.5%). The failure of trade to redistribute supplies in the

Table 6. **Consumption Regression, Selected Asian Economies—Dependent Variable: Log of Change in Rice Consumption**

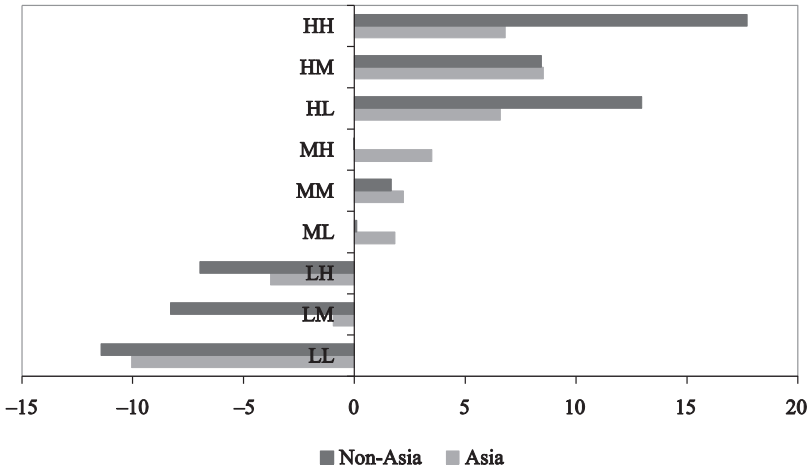
Variable	Coefficient	Standard Error	t-value	Coefficient	Standard Error	t-value
Dummy variable for negative domestic yield shock and negative foreign yield shock	−0.169	0.034	−4.92	−0.185	0.010	−18.64
Dummy variable for negative domestic yield shock and mid-range foreign yield shock	−0.078	0.022	−3.52	−0.088	0.040	−2.21
Dummy variable for negative domestic yield shock and positive foreign yield shock	−0.106	0.025	−4.16	−0.119	0.041	−2.89
Dummy variable for mid-range domestic yield shock and negative foreign yield shock	−0.050	0.021	−2.34	−0.057	0.030	−1.93
Dummy variable for mid-range domestic yield shock and mid-range foreign yield shock	−0.046	0.020	−2.27	−0.052	0.027	−1.91
Dummy variable for mid-range domestic yield shock and positive foreign yield shock	−0.033	0.022	−1.54	−0.041	0.024	−1.70
Dummy variable for positive domestic yield shock and negative foreign yield shock	−0.002	0.025	−0.09	−0.016	0.020	−0.81
Dummy variable for positive domestic yield shock and mid-range foreign yield shock	0.017	0.022	0.77	0.000	0.027	0.00
Dummy variable for positive domestic yield shock and positive foreign yield shock	(omitted)			(omitted)		
Lagged dependent variable (first order)				−0.235	0.102	−2.31
Lagged dependent variable (second order)				−0.144	0.085	−1.70
Constant	0.068	0.020	3.43	0.087	0.028	3.13

Notes:
1. The number of observations is 306 (288 for specification with lagged dependent variables).
2. The sample consists of six economies for 1960–2010: Bangladesh, the People's Republic of China, India, Indonesia, the Philippines, and Viet Nam.
3. The regression uses economy fixed effects.
4. The specification with lagged dependent variables has been estimated with the Arellano–Bond method using second- to sixth-order lags of the dependent variable as instrumental variables.
Source: Authors' estimates.

latter scenario seems to be the reason why trade is not able to stabilize consumption in economies hit by negative domestic shocks even when world supplies are ample.

Table 6 is the consumption regression for some of the Asian economies that are important in the world rice economy: Bangladesh, the PRC, India, Indonesia,

Figure 3. **Percentage Change in Rice Consumption—Asian versus Non-Asian Economies**



Notes: Each scenario is denoted as XY, where the domestic shock X = {H, M, L} and the foreign shock Y = {H, M, L}. H, M, and L represent the positive, mid-range, and negative shocks, respectively.
Source: Authors' estimates.

the Philippines, and Viet Nam. Pakistan and Thailand are excluded.[5] Once again, the implied rates of consumption change do not vary greatly between the two specifications.

Figure 3 compares the average percentage change in rice consumption in each of the shock scenarios for the Asian sample and for all other economies in the sample. Each scenario is denoted as XY, where the domestic shock X = {H, M, L} and the foreign shock Y = {H, M, L}; and H, M, and L represent the positive, mid-range, and negative shocks, respectively. The horizontal bars represent the percentage change in rice consumption in each of the nine scenarios. For instance, the bars at HH show that when domestic and foreign yield shocks are both positive, average rice consumption in Asia increases by about 7%, while average consumption in non-Asian economies increases by more than 15%. The percentage changes are derived from Table 6 and a similar regression for the non-Asian economies that is not reported here.[6] In both of these regressions, the base category is the HH scenario and therefore the percentage change here is given by the coefficients of this category in the regressions. For the other scenarios, the coefficient of each category is added to the coefficient of the dummy for the HH category to obtain the percentage change in consumption.

The common finding is that rice consumption declines are substantial and comparable in the scenarios of negative domestic and foreign shocks. However,

[5]Exports as a proportion of consumption are greater than 50% in both Pakistan and Thailand. The vulnerability of domestic consumption to yield shocks is not a major concern here.

[6]Results are based on coefficient estimates for the specification that does not include lagged values of the dependent variable as regressors.

Asian economies seem to do better in arresting consumption declines in scenarios involving negative domestic yields. The most striking difference involves the positive domestic yield scenarios: consumption growth in the Asian economies is lower than in the world sample. This could be due to either exports or the buildup of domestic stocks. The latter seems more likely because, as in the world sample, the difference in consumption growth between the scenarios of positive and negative foreign shocks (given a positive domestic shock) is small. Domestic stocks, in turn, may have enabled these economies to stabilize consumption when domestic shocks are negative. Yet, even this policy has not been successful when negative domestic shocks are accompanied by negative foreign shocks. Another possible explanation for consumption smoothing could be unregulated rice trading and smuggling in Asian economies such as the PRC, Indonesia, Kazakhstan, Myanmar, the Philippines, Thailand, and Viet Nam (Chen 2008, Mon 2015).

VI. Policy Response

Negative domestic shocks occur when stabilization fails to take place. Access to world markets helps, but consumption declines even when foreign yields are high. These are reduced form results based on the outcome of both trade and domestic stabilization policies. To understand how trade and domestic policies modify exogenous shocks, we consider the following regression model for economy j and year t:

$$\ln\left(\frac{C_{jt}}{C_{j,t-1}}\right) = \beta_1 + \beta_{2jt}DY_{jt} + \beta_{3jt}FY_{jt} + \beta_4 DS_{jt} + \beta_5 FS_{jt} + \theta_j + \varepsilon_{jt} \qquad (1)$$

where C is rice consumption; DY and FY are domestic and foreign yield shocks, respectively; DS and FS are the domestic and rest-of-the-world stocks, both as proportions of domestic and rest-of-the-world consumption, respectively, at the beginning of year t; and θ_j is an economy fixed effect. Earlier, we explained how shocks were constructed.

In our data, the policy variable is the level of stocks in each economy.[7] Clearly, trade restrictions will have a direct impact on stocks. For each economy, we construct a domestic stock variable and a foreign stock, which is an aggregate of stocks in the rest of the world. We allow the coefficients of domestic and foreign yield shocks to vary with domestic stocks and foreign stocks:

$$\beta_{2jt} = \gamma_1 + \gamma_2 DS_{jt} + \gamma_3 FS_{jt} \qquad (2)$$

[7] The reliability of stocks data is open to question. This caveat applies to the empirical analysis that follows.

Table 7. **Consumption Regression with Yield Shocks and Stocks—Dependent Variable: Log of Change in Rice Consumption**

Variable	Coefficient	Standard Error	t-value
Lagged dependent variable (first order)	−0.341	0.033	−10.39
Lagged dependent variable (second order)	−0.127	0.030	−4.25
Domestic stock/Consumption	0.293	0.096	3.05
Foreign stock/Foreign consumption	0.243	0.247	0.98
Domestic yield shock	0.195	0.079	2.46
Foreign yield shock	0.234	0.671	0.35
Domestic shock × (Domestic stock/Domestic consumption)	−0.095	0.040	−2.39
Domestic shock × (Foreign stock/Foreign consumption)	0.115	0.298	0.39
Foreign shock × (Domestic stock/Domestic consumption)	−0.697	0.363	−1.92
Foreign shock × (Foreign stock/Foreign consumption)	−0.052	2.832	−0.02
Constant	−0.058	0.060	−0.98

Notes:
1. The number of observations is 3,885 for 87 economies.
2. The regression uses economy fixed effects.
3. The model has been estimated with the Arellano–Bond method using second- to sixth-order lags of the dependent variable as instrumental variables.
Source: Authors' estimates.

and similarly,

$$\beta_{3jt} = \delta_1 + \delta_2 DS_{jt} + \delta_3 FS_{jt} \tag{3}$$

Based on our previous findings, we expect the coefficient of domestic yield, γ_1, to be positive. We also expect the coefficient of foreign yield, δ_1, to be positive but not as large as γ_1. Since domestic stocks are expected to soften the effect of yield shocks, the coefficients γ_2 and δ_2 are expected to be negative. Domestic stocks are also likely to have a direct positive impact on consumption; hence, we expect a positive sign for β_4. It is not clear a priori how the level of foreign stocks might affect domestic consumption, either directly or indirectly, by impacting how yield shocks affect consumption.

The results are presented in Table 7. Both domestic shocks and domestic stocks have a positive impact on the change in consumption and are statistically significant. Foreign yields and foreign stocks are not significant. The interaction term involving domestic shocks and domestic stocks is significantly negative. This shows that domestic policies moderate the impacts of domestic shocks.

An alternative specification replaces both shock variables by the dummies representing negative, mid-range, and positive shocks as defined earlier. Both sets of dummies are interacted with domestic and foreign stocks. This allows policies to interact with shocks in a nonlinear manner. This specification is estimated in Table 8. The omitted base category in the table is the combination of mid-range domestic and mid-range foreign yield shocks.

Table 8. **Consumption Regression with Yield Shocks and Stocks—Dependent Variable: Log of Change in Rice Consumption**

Variable	Coefficient	Standard Error	t-value
Lagged dependent variable (first order)	−0.338	0.032	−10.53
Lagged dependent variable (second order)	−0.119	0.030	−3.99
Domestic stock/Consumption	0.272	0.087	3.12
Foreign stock/Foreign consumption	0.253	0.289	0.88
Negative domestic shock	−0.145	0.039	−3.75
Negative domestic shock × (Domestic stock/Consumption)	0.093	0.043	2.14
Negative domestic shock × (Foreign stock/Foreign consumption)	0.124	0.127	0.97
Positive domestic shock	0.050	0.047	1.04
Positive domestic shock × (Domestic stock/Consumption)	−0.096	0.046	−2.10
Positive domestic shock × (Foreign stock/Consumption)	0.150	0.172	0.88
Negative foreign shock	−0.009	0.035	−0.26
Negative foreign shock × (Domestic stock/Consumption)	0.071	0.059	1.21
Negative foreign shock × (Foreign stock/Foreign consumption)	−0.050	0.140	−0.36
Positive foreign shock	0.044	0.031	1.40
Positive foreign shock × (Domestic stock/Consumption)	−0.010	0.033	−0.29
Positive foreign shock × (Foreign stock/Foreign consumption)	−0.236	0.136	−1.73
Constant	−0.054	0.070	−0.76

Notes:
1. The number of observations is 3,885 for 87 economies.
2. The regression uses economy fixed effects.
3. The model has been estimated with the Arellano–Bond method using second- to eighth-order lags of the dependent variable as instrumental variables.
Source: Authors' estimates.

Like in the previous specification, foreign stock is not significant either by itself or when interacted with shocks. Relative to the base category, the decline in the growth of rice consumption in the event of a negative domestic shock is $0.272DS + 0.253FS + (-0.145 + 0.093DS + 0.124FS)$, where DS and FS are domestic and foreign stock ratios, respectively. The coefficients of both stock variables (in their interaction with negative domestic shock) are positive, suggesting that stocks—domestic and foreign—help in moderating the decline in rice consumption. However, the interaction of a negative domestic shock with foreign stock is not significant. Neither is the foreign stock coefficient by itself.

On the other hand, the domestic stock variable is significant in itself and in its interaction with a negative domestic shock. The combined effect is $0.365DS$. The median value of domestic stocks as a proportion of consumption is 0.05. This means that its contribution in reducing the hit on consumption is about 1.8 percentage points. The 75-percentile level of stocks is 0.2. At this level, stocks would arrest the decline in consumption by 7.3 percentage points. Domestic stocks would have to be about 40% of consumption to wipe out the 14.5% decline in rice consumption (relative to base category) that is due to negative domestic shocks. Thus, while domestic stabilization policies through grain reserves have moderated consumption declines, their contribution at the median level of stocks is limited.

VII. Concluding Remarks

There is considerable literature about world price volatility and the transmission of world prices to domestic prices. In this paper, we have taken a different route to assess stability and examine the role of trade and domestic stabilization policies. For each economy, we constructed exogenous domestic and foreign (i.e., rest of the world) yield shocks and looked at their impacts on rice imports and rice consumption. We also considered how these impacts were modified by domestic and foreign stocks.

If supply shocks are uncorrelated across economies, the global supply is essentially stable. Provided that there are no demand shocks, the global price is also stable. Importing economies would be able to import whenever they need to and at a stable price. Even if shocks are correlated across economies, as long as the correlation coefficient is less than 1, the global aggregate supply is much more stable than individual economy supplies.

Although trade cannot be expected to play a strong role when the major producing and consuming economies are simultaneously hit by negative yield shocks, such a scenario occurs in only about 3% of observed cases. In all other cases of negative domestic shocks, they can be at least partially neutralized by positive foreign shocks. This implies that in a world of free trade, consumption levels in individual economies would be stabilized. However, our study finds that this is not the case. In cases of adverse domestic shocks, consumption fails to be stabilized even when foreign shocks are positive; however, imports do peak. Thus, while trade does help in coping with domestic risks, it is unable to achieve full risk sharing. The flip side is that when domestic yield shocks are positive, consumption surges even when the shock in the rest of the world is negative.[8] Therefore, irrespective of foreign shocks, the principal concern for poor economies is to stabilize consumption when hit by negative domestic yield shocks. The frequency of such shocks is about 12%.

Domestic policies have played a greater role in stabilizing the adverse impacts of negative shocks. This could be because of the presumed unreliability of the rice trade. Storage is expensive, however, and economies often follow ad hoc rules of thumb and tend to carry too much stock either because of extreme precaution or because these policies have been captured by producer interests (Gilbert 2011, Knudsen and Nash 1990).[9] A judicious combination of stocks and trade can be an effective tool to stabilize domestic prices, but at the cost of higher global price volatility (Gouel and Jean 2015). Otherwise, reliance on domestic stabilization will continue to keep rice markets thin and promote market insulation policies similar to those that led to the rice price spike in 2007–2008.

[8] As a referee points out, this could be a statistical artifact since changes in private stocks are not measured and are therefore included in consumption.

[9] For a review of the Indian experience, see Ramaswami and Murugkar (2013).

Cooperative solutions such as common food reserves could also serve as the region's insurance in times of food crises. Toward this end, the Association of Southeast Asian Nations (ASEAN) has made progress in adopting a framework to set aside and share rice stocks for contingencies. ASEAN includes some of the world's largest importers (Indonesia and the Philippines) and exporters (Thailand and Viet Nam), as well as Myanmar, which is aspiring to regain its status of the 1950s as the world's largest exporter of rice. While contingency stocks may be a good initiative to address crises in individual economies, they are inadequate to deal with crises of regional proportions. To succeed, the region must establish a mechanism to mobilize collective action and cooperation, especially when a shock affects multiple economies simultaneously (Jha and Rhee 2012).

A positive development in the world rice market is the greater volume of trade achieved since the mid-1990s due to export liberalization in India and the entry of Viet Nam into world markets. Can there be another shift upward? Surpluses in commercial rice-exporting economies such as Thailand, Pakistan, and the US are already high. Exports are as high as domestic consumption in Thailand and Pakistan, while in the US, the ratio is close to 60%. That is why the thickening of the rice market had to depend on new exporters such as India and Viet Nam.

Between 2006 and 2008, Viet Nam's exports were consistently around 21% of consumption. However, Indian exports have varied between 2.5% and 6% of domestic consumption. Not only has India's contribution to world exports varied, but its surpluses have also been small relative to domestic consumption. Negative domestic shocks and domestic policies can shrink these surpluses quickly. Similarly, in other large rice-producing economies such as Bangladesh, the PRC, and Indonesia, the surpluses or deficits are small relative to consumption. It is not clear whether these economies can be reliable contributors to global supplies in the future. In addition, climate change poses unknown perils to some of the major rice growing regions in Bangladesh and India.

In this sense, the rise of Viet Nam is reassuring to the long-term future of the world rice market, although its surpluses are not as large as in Thailand. While surpluses may continue to rise in Viet Nam, especially with rising prosperity, the emergence of surpluses in other economies might be needed for the rice market to thicken. Myanmar and Cambodia are possible candidates for exporting rice. As the PRC becomes a net importer, low-income economies in the Greater Mekong Subregion in Southeast Asia hold significant potential to increase productivity and contribute to dramatic regional trade expansion (Jha et al. 2010). But this can only be realized if policies are integrated and complementary.

High and volatile global prices can generate panicked herd behavior. Experience shows that antitrade bias in agricultural policies, such as price-insulating export restrictions and aggressive importations, contribute significantly to world price increases. Historically, food price volatility has been higher when trade has been impeded (e.g., during the two world wars, the breakdown of Bretton Woods

in the 1970s, and the global food price crisis in 2007–2008). Restoring confidence in the food trade is the key, but binding economies to agree multilaterally to limit trade restrictions—though plausible—does not seem feasible at present. Regional or bilateral agreements among Asian economies, which produce and consume over 90% of the world's rice, could perhaps be the starting point. However, even within ASEAN, progress in cooperation remains limited despite the great potential for raising productivity, production, and food security.

While it may seem that a more reliable rice-trading system would have to await greater productivity increases in some of the key rice-producing regions of the world, developing economies are also seeing a major paradigm shift in social safety net policies. The emphasis has shifted from commodity subsidies and market interventions to cash transfers. The shift in these policies is made possible by continuing developments in information and communication technologies. It is plausible that these trends may lead developing economies to de-emphasize grain stocks, which in turn could lead the rice trade to grow. However, as grain prices matter to the value of cash transfers, they will continue to be a high priority on the economic and political agenda of developing economies.

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*ADB recognizes "China" as the People's Republic of China.

Typhoon Aid and Development: The Effects of Typhoon-Resistant Schools and Instructional Resources on Educational Attainment in the Philippines

Ava Gail Cas*

This paper examines the effects on educational attainment of assistance programs that provided typhoon-resistant secondary schools and instructional resources in the Philippines. Using the variation in the availability of assistance programs and differences in exposure across age cohorts induced by the timing of the allocation of program packages, I find positive and statistically significant impacts on education outcomes for both boys and girls. For boys, the presence of typhoon-resistant schools equipped with instructional resources led to an average increase of 0.26–0.31 years of education, while the presence of instructional resources alone led to an average increase of 0.23–0.26 years of education. For girls, the availability of both components led to an average increase of 0.23–0.32 years of education, while the availability of either component alone did not seem to have an effect.

Keywords: aid, instructional resources, school building, schooling, typhoons
JEL codes: I25, O15

I. Introduction

The question of whether access to schools and instructional resources enhances human capital outcomes is of interest to economists. A number of economists have examined the effects of an expansion in the number of schools and classrooms on educational attainment, wages, fertility, and child health (Breierova and Duflo 2004, Chou et al. 2010, Duflo 2001, Osili and Long 2008). In the United States (US), economists have looked at the effect of a comprehensive school construction program on test scores, enrollment, and housing prices (Neilson and Zimmerman 2014). Meanwhile, a growing number of studies have investigated

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the impact on student learning of technology-related instructional resources. For instance, Angrist and Lavy (2002) and Barrow, Markman, and Rouse (2009) investigate whether providing computers for pedagogical use in the classroom improves reading, mathematics, and algebra test scores in Israel and the US, while Beuermann et al. (2015) examine the impact of the One Laptop per Child program on children's cognitive test scores in Peru.

However, given the scarcity of resources in many developing economies, even access to basic instructional resources to assist student learning in the subjects of math and science is limited. In terms of school infrastructure, often the issue is not access to schools, but rather access to good quality schools (that are, for example, typhoon resistant), particularly in economies that are prone to natural disasters. Earlier research suggests that the destruction of school infrastructure can lead to a loss of human capital, especially with regard to permanent and unrepaired damages (Baez and Santos 2009).

In this paper, I evaluate the long-term impact of a bilateral program that constructed typhoon-resistant secondary schools and provided instructional materials for major high school subjects (e.g., biology, chemistry, home economics, mathematics, physics, and technology) in typhoon-affected parts of the Philippines. The importance of typhoon-resistant schools cannot be understated in disaster-prone economies such as the Philippines. Lying astride the "typhoon belt" in the Pacific Ocean, the Philippines is the most typhoon-affected country in the world with an average of 20 typhoons each year, of which an average of six are classified as extreme or destructive with maximum sustained winds of at least 150 kilometers per hour.[1] Municipalities that sustain direct hits from typhoons tend to sustain severe damage to their infrastructure. The loss of school infrastructure can disrupt schooling for an extended period of time, especially if buildings and facilities are permanently damaged or left unrepaired. In cases where regular classes are disrupted for several weeks during the reconstruction period, a loss of human capital is inevitable. When instruction time is lost, the quality of learning may also decline. Some students may find it difficult to catch up and eventually drop out of school. At the same time, the loss of instructional resources may also affect the quality of student learning.

I examine the impacts on educational attainment of typhoon-resistant school construction and instructional materials assistance program in the Philippines 10 years after their initial implementation. The results of my analysis suggest that for boys, the presence of typhoon-resistant secondary schools equipped with instructional resources led to an average increase of 0.26–0.30 years of education, while the presence of instructional resources alone led to an average increase of

[1] This is based on data from PAGASA. Tropical cyclones in the western Pacific Ocean are called typhoons, while tropical cyclones in the Atlantic Ocean and eastern Pacific Ocean are called hurricanes. Typhoons are generally very strong, because of the western Pacific's warm water, and occur more frequently than hurricanes.

0.23–0.26 years of education. For girls, the availability of both components led to an average increase of 0.23–0.32 years of education, while the availability of either component alone did not seem to have an effect. Estimates are robust for the inclusion of individual-level characteristics and when accounting for concurrent national government programs, restricting to municipalities in the Philippines typhoon-affected regions, and accounting for municipality-specific trends.

The paper contributes to the literature in a number of ways. First, to the best of my knowledge, it is the first study to assess the effects of disaster-resistant secondary schools and instructional resources for math and science at the population level. The paper qualifies the separate effects of typhoon-resistant schools and instructional resources in addition to examining the cumulative impacts when both components are present. Second, it adds to the growing literature that independently evaluates the longer-term impacts of grant assistance and loan programs using microlevel data, given that development assistance efforts are generally evaluated at the project level during implementation by the same aid agencies and institutions that are providing funding. One exception is the evaluation of a World Bank-financed rural development program 10 years after its implementation by Chen, Mu, and Ravallion (2009), who found only small and statistically insignificant gains on mean consumption in the long-term. Third, this paper evaluates an innovative policy solution for mitigating the risks of natural disasters. As global warming proceeds, many economies will continue to experience extreme weather conditions that can affect human capital accumulation. The destruction of secondary schools due to natural disasters is of particular importance since children at this age are more likely than affected primary school children to transition from schooling to work and family formation, especially if they have also lost one or both parents due to natural disaster (Cas et al. 2014). Thus, it is important to continually develop and evaluate innovative solutions to protect secondary school children from disruptions to their education.

The rest of the paper is organized as follows. Section II provides background on the secondary education reform program, which was launched in 1988 with Japanese grant assistance and comprised a typhoon-resistant school building program and an instructional materials distribution program. Section III presents the data and results for the determinants of program placement. Section IV provides an identification strategy. Section V presents the results and section VI concludes and discusses policy implications.

II. Secondary Education Reform and the Typhoon-Resistant School Building and Instructional Equipment Programs

In 1988, the Philippines implemented a free public secondary education policy to complement its historically free and compulsory public elementary education

policy.[2] Under the new policy, tuition and matriculation fees, laboratory and library fees, medical and dental fees, and athletic fees were all waived for secondary education. Thus, the policy led to a rapid increase in secondary school enrollment and a shortfall in classrooms and school buildings. Part of the reason for the shortage of classrooms was that school infrastructure in some provinces had been severely damaged by two super-typhoons in 1987. Given these capacity constraints, Department of Education officials prioritized the enrollment in secondary schools of graduates of public elementary schools in the same municipality, as well as returning students in the second, third, and fourth years of secondary school.[3]

In that same year, the government explored the possibility of tapping Japanese bilateral grant assistance to supplement its initiatives to address the shortage of classrooms and other school facilities. This resulted in the launching of a school building project in 1989—the Typhoon-Resistant School Building Program (TRSBP)—that used Japanese technology for constructing typhoon-resistant, prefabricated structures. The idea behind TRSBP was to not just build more schools to increase classroom capacity, but to build better infrastructure so that schooling would not be interrupted by damage caused by the typhoons that regularly affect the Philippines. TRSBP was an unusual assistance program as the Government of Japan provided an in-kind grant for its implementation. Thus, Japanese firms constructed all of the school infrastructure using prefabricated materials that were transported to the Philippines from Japan. A total of 252 public secondary schools, including 902 classrooms and 153 science rooms and workshops, were constructed under TRSBP, mainly in those regions most affected by typhoons.[4] On average, each school construction project represented an investment worth P7.4 million–P11.1 million.[5]

The major consideration for the selection of provinces participating in TRSBP was that a province must have been heavily affected by past typhoons, particularly one of the two super-typhoons in 1987. The guidelines used for selecting the recipient municipalities and schools were as follows: (i) the school should have sufficient space to build on; (ii) the school should be located in or near large population centers; (iii) the municipality should not be a recipient or prospective recipient of financial aid for disaster relief or disaster mitigation from any other foreign aid agency, or from the Philippine government's existing school-building program or calamity fund; and (iv) the school should not have received more than P300,000 from the government

[2]The Philippines has a long history of free and compulsory elementary education that dates back to 1898 when a new constitution was established after the expulsion of the Spanish regime from the Philippines.

[3]The Philippines has a 6–4–4 education system, with six years of elementary education, 4 years of secondary education, and 4 years of tertiary education.

[4]The program also constructed schools at the elementary level, although the secondary level was prioritized. Overall, a total of 360 elementary and secondary schools were constructed, including 1,289 classrooms and 219 science rooms.

[5]In 1990, one US dollar was equivalent to P47.08. Thus, the average investment per school under TRSBP was equivalent to about $157,000–$236,000. About 5.4% of the total project cost was appropriated to consultancy fees.

in addition to its regular budget. The design criteria for building the schools include an emphasis on typhoon resistance, flood resistance, flexibility for multiple uses, adaptation to tropical climate conditions, meeting the requirements of handicapped students, ease of maintenance, and a systematized construction process in order to complete each project in 1 year and with uniform quality. TRSBP also considered the availability of water, power, and sewerage to ensure properly functioning classrooms, laboratories, and sanitation facilities within the schools. If basic facilities such as power and electrical lines, and water and sewerage systems were insufficient, new basic facilities could be installed in some cases.

In addition to TRSBP, the Philippine government also requested from the Japanese government grant assistance for the provision of instructional materials and equipment, which became known as the Secondary Education Instructional Equipment Program (SEIEP).[6] With the goal of increasing access to quality education and developing students' curiosity in natural science and technology, the Department of Education aimed to address the shortage of experimental and training equipment to improve the teaching of science and technology, as well as home economics. One of the basic criteria used in the SEIEP selection process was that a recipient school should also be enrolled in TRSBP, although not all TRSBP recipient schools would benefit from SEIEP. Furthermore, SEIEP would end up providing instructional equipment to some non-TRSBP recipient schools.[7] The other criteria used in the SEIEP selection process were as follows: (i) the school should not receive any facilities or equipment assistance from any other local or foreign sources, and (ii) the school should have an enrollment of more than 200 students.

Therefore, the bilateral grant assistance from the Government of Japan led to three types of program packages for recipient schools, each of which will be evaluated in this paper: (i) TRSBP only, (ii) SEIEP only, and (iii) TRSBP and SEIEP.

A. Concurrent Programs

Besides tapping Japanese grant assistance, the Philippine government also obtained loans from the Asian Development Bank (ADB) and assistance from the United States Agency for International Development (USAID) to construct approximately 2,145 classrooms at 675 schools in other parts of the country. These schools also received instructional equipment packages to meet the Philippine government's goal of raising the quality of education and developing student interest

[6]To ensure the proper use and maintenance of the equipment, a 3- to 5-day teacher training was conducted at each recipient school by a project team comprising representatives from the Philippine and Japanese governments.

[7]Similar to TRSBP, the program considered the availability of electrical and water utilities. In cases where these basic facilities were insufficient, the Government of the Philippines could provide the necessary electrical system and water supply assistance packages.

in the natural sciences and technology. However, unlike the TRSBP schools, these schools were constructed using materials that were similar to that used by the government under its regular school-building program. The rest of the municipalities that did not receive assistance under either TRSBP or ADB- or USAID-funded programs were covered under the government's regular school-building program.[8]

A separate program, the National Secondary Education Curriculum, was implemented beginning in 1993 and was phased in across various municipalities. As part of the government's secondary education reform policy, it may have potentially been correlated in some municipalities with the allocation of typhoon-resistant schools and/or instructional equipment packages. Unfortunately, I do not have data on the recipient municipalities of National Secondary Education Curriculum assistance. Thus, to estimate the impact of the Japanese grant assistance programs, I will restrict my analysis to program packages allocated before 1992.

At around the same time, the government launched a water supply, sanitation, and sewerage master plan for the period 1988–2000. The goal of this plan was to provide basic water supply facilities (e.g., wells) in 37 of the Philippines' 83 provinces and sanitation facilities (e.g., household latrines, public toilets, sullage removal units, disinfections) in 75 provinces. The specifications of this paper will also account for the presence of assistance programs under the water supply, sanitation, and basic water supply facilities master plan since they operated concurrently with TRSBP and SEIEP.

III. Data and Determinants of Typhoon-Resistant School Building Program Recipient Municipalities

The main data source for this paper is the 10% Integrated Public Use Microdata Series (IPUMS) of the Philippines decennial censuses. The 2000 IPUMS is the main data used in regression estimates, while the 1990 IPUMS is used to construct variables predicting the determinants of program availability. Data on the recipients of TRSBP and SEIEP assistance were obtained from project completion reports made available by the Educational Development Projects Implementing Task Force of the Philippines' Department of Education. These reports provide a complete list of schools receiving assistance under the two programs and their corresponding allocations by municipality. The Manual on Secondary Education Development, published by the Department of Education, also provides a list of recipient schools and municipalities under ADB- and USAID-funded school-building projects. Data on the water and sanitation programs are at the provincial level and were obtained

[8] Since these schools could potentially be damaged or destroyed by a typhoon, part of the funding under the regular school-building program was used to repair school buildings and classrooms that had been severely damaged by typhoons.

Table 1. **Summary Statistics at the Municipality Level**

	Type of Assistance				P-values		
Variables	**TRSBP (1)**	**SEIEP (2)**	**Both (3)**	**None (4)**	**Diff. (1)–(4)**	**Diff. (2)–(4)**	**Diff. (3)–(4)**
% impacted by super-typhoon in 1987	0.52 (0.50)	0.77 (0.43)	0.68 (0.47)	0.19 (0.39)	0.00	0.00	0.00
Nonenrollment rate in 1989 (13–16-year olds)	0.40 (0.10)	0.46 (0.11)	0.44 (0.09)	0.40 (0.11)	0.80	0.00	0.01
Average years of education (25–40-year olds)	7.97 (1.26)	7.16 (1.13)	7.45 (0.88)	7.62 (1.55)	0.09	0.05	0.44
Average % of individuals who work in agriculture sector	0.26 (0.13)	0.34 (0.12)	0.33 (0.10)	0.29 (0.15)	0.19	0.00	0.05
% with electricity	0.55 (0.26)	0.30 (0.20)	0.40 (0.13)	0.46 (0.27)	0.02	0.00	0.13
% with piped water	0.33 (0.24)	0.38 (0.21)	0.35 (0.19)	0.29 (0.22)	0.27	0.00	0.10
% land owners	0.55 (0.17)	0.48 (0.13)	0.47 (0.12)	0.54 (0.16)	0.61	0.00	0.00
% own dwelling	0.88 (0.08)	0.88 (0.05)	0.89 (0.05)	0.88 (0.09)	0.99	0.49	0.41
% with television	0.31 (0.25)	0.09 (0.11)	0.12 (0.09)	0.25 (0.23)	0.09	0.00	0.00
% with radio	0.69 (0.11)	0.59 (0.11)	0.62 (0.07)	0.68 (0.10)	0.68	0.00	0.00
% with toilet	0.57 (0.22)	0.42 (0.19)	0.51 (0.17)	0.51 (0.25)	0.07	0.15	0.85
% roof made of metal	0.56 (0.27)	0.25 (0.11)	0.26 (0.09)	0.48 (0.26)	0.02	0.00	0.00
% walls made of wood	0.62 (0.20)	0.76 (0.11)	0.73 (0.10)	0.68 (0.22)	0.02	0.01	0.15
Observations	60	46	50	916			

Notes: Variable mean displayed to the right of variable name. Standard deviations displayed in parentheses below the mean.

Sources: Minnesota Population Center. 2015. *1990 Integrated Public Use Microdata Series, International: Version 6.4.* Minneapolis: University of Minnesota; Government of the Philippines, Department of Education. 1995. *Project Completion Report: Typhoon-Resistant School Building Program.* Manila; Government of the Philippines, Department of Education. 1995. *Project Completion Report: Secondary Education Instructional Equipment Program.* Manila.

from project completion reports under the Rural Water and Sanitation Services Program funded by ADB and the World Bank. I also obtained data on typhoons and tropical storms affecting the Philippines in 1980–2000 from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). The data include areas affected as well as the corresponding strength of each typhoon and tropical storm affecting the Philippines during this period.

As expected, the municipalities that received assistance under TRSBP, SEIEP, or both programs were heavily impacted by one or both of the super-typhoons in 1987 (Table 1). Of the municipalities that received TRSBP assistance, 52% were typhoon affected; of those that received SEIEP assistance, 77% were typhoon affected; and of those that received assistance under both programs, 68% were typhoon affected.

This is consistent with the primary requirement of the Japanese grant assistance program which was to channel aid to the most typhoon-affected areas.

In general, the municipalities that received SEIEP assistance packages tended to have the highest nonenrollment rates among 13–16-year olds, the lowest percentage of educated adults among 25–40-year olds, and the highest share of the population engaged in agriculture. They also tended to be the poorest municipalities based on various indicators such as percentages with electricity, television, radio, toilet, roof made of metal, or walls made of wood. This pattern was also observed among municipalities that received both SEIEP and TRSBP assistance packages, with these municipalities ranking second to SEIEP-only municipalities in terms of nonenrollment rates, education level of adults, share of the population engaged in agriculture, and socioeconomic status. Meanwhile, the municipalities that received only TRSBP assistance had the lowest nonenrollment rates among 13–16-year olds, which were similar to municipalities receiving no assistance; highest share of educated adults; lowest share of the population engaged in agriculture; and the highest socioeconomic status.

IV. Identification Strategy

To investigate the impact of these unique grant assistance programs on education, I use a difference-in-difference framework comparing the evolution of schooling outcomes by age cohorts. Specifically, the two age cohorts comprise students that were fully exposed to these program packages in 1989 (9–12-year olds) versus those that had little or no exposure to the program in 1989 (17–20-year olds) in municipalities with and without access to the three types of program packages: (i) TRSBP only, (ii) SEIEP only, and (iii) both programs.[9]

This suggests estimating an equation of the following general form:

$$Y_{impt} = \alpha_1 TRSBP_m T + \alpha_2 SEIEP_m T + \alpha_3 Both_m T + \alpha_4 X_{impt} + \alpha_4 Z_m T + \delta_m + \gamma_t + \epsilon_{imt} \quad (1)$$

where Y_{impt} is the years of schooling of person i residing in municipality m in 1990 and age t in 1989; $TRSBP_m$ is a dummy variable indicating whether the municipality received TRSBP assistance only and 0 otherwise; $SEIEP_m$ is a dummy variable indicating whether the municipality received SEIEP assistance only and 0 otherwise; $Both_m$ is a dummy variable indicating whether the municipality received both packages and 0 otherwise; T is a dummy variable indicating whether the individual was 9–12 years old or 17–20 years old in 1989; X_{imt} refers to individual-level characteristics such as religion and ethnicity; Z_m is the vector of variables such as

[9] In 2000, educational attainment was assessed for 20–23-year olds and 28–31-year olds.

the availability of ADB and USAID school assistance packages and water supplies and sanitation facilities; δ_m refers to the 1990 municipality of residence fixed effect; and γ_t refers to the age-cohort dummies. In this specification, the parameters of interest are α_1, α_2, and α_3, which correspond to the interaction between the age-group dummy T and each of the three possible program packages being reviewed. This paper also provides separate analysis for boys and girls.

In the Philippines, children typically enter secondary school at age 13 and finish by age 16. Based on administrative data from the Department of Education, less than 5% of the population of 17–24-year olds were enrolled in secondary school during the 1988/89 school year. Hence, the effects of the aid programs should be relatively close to 0 for these individuals. On the other hand, children who were 12 years old or younger in 1988/89 would soon be entering secondary school and therefore had the potential to be fully exposed to the programs.

Could it be that a student's advanced learning abilities or determined parents led in some cases to a student being enrolled in a secondary school other than one in his or her own municipality? Could the families of some students have simply migrated to those municipalities that were receiving aid? As mentioned in section II, the government mandates that secondary schools prioritize the enrollment of graduates of public elementary schools in the same municipality as well as returning students in the second, third, and fourth years of the same secondary school. Thus, it would have been difficult at that time for a student to be enrolled in a secondary school in another municipality, particularly for the first few years of the program, which are the subject of analysis of this paper.

To deal with the migration issue, I use the municipality of residence of the individual in 1990, which is available in the 2000 IPUMS. To further examine the migration patterns of individuals in the sample prior to 1990 (aged 9–12 years and 17–20 years in 1989), I use the 1990 IPUMS question asking for the number of years a person has resided in their current municipality. In general, less than 3% of individuals in the sample had been living in a municipality for less than 1 year in 1990, which may have represented people who migrated to another municipality in 1989 when the program started, while less than 5% had been living in their municipality for less than 3 years in 1990, which may have represented people who migrated to another municipality in the aftermath of the super-typhoons in 1987. These statistics suggest that migration is not likely to have driven the results.

V. Results and Discussion

A. Main Results

Table 2 presents the average educational attainment in years by program package, age group, and gender. Following the pattern observed in Table 1, regardless

Table 2. **Average Educational Attainment in Years by Program and Age Cohort**

Boys					**Difference**		
Age in 1989	**TRSBP**	**SEIEP**	**Both**	**None**	**TRSBP–None**	**SEIEP–None**	**Both–None**
9–12 years	9.38	8.62	8.7	9.24	0.14	−0.61	−0.53
	[0.03]	[0.04]	[0.04]	[0.01]	[0.03]	[0.04]	[0.04]
17–20 years	9.06	7.97	7.99	8.91	0.15	−0.93	−0.91
	[0.03]	[0.05]	[0.04]	[0.01]	[0.04]	[0.05]	[0.05]
Difference	0.32	0.65	0.71	0.33	−0.01	0.32***	0.38***
	[0.04]	[0.07]	[0.06]	[0.01]	[0.05]	[0.07]	[0.06]
Obs.	22,188	11,597	14,333	333,167			
Girls					**Difference**		
Age in 1989	**TRSBP**	**SEIEP**	**Both**	**None**	**TRSBP–None**	**SEIEP–None**	**Both–None**
9–12 years	10.15	9.34	9.69	9.96	0.19	−0.61	−0.26
	[0.03]	[0.04]	[0.04]	[0.01]	[0.03]	[0.04]	[0.04]
17–20 years	9.45	8.61	8.66	9.29	0.16	−0.68	−0.63
	[0.03]	[0.05]	[0.04]	[0.01]	[0.04]	[0.05]	[0.05]
Difference	0.70	0.73	1.03	0.67	0.03	0.06	0.36***
	[0.04]	[0.07]	[0.06]	[0.01]	[0.05]	[0.07]	[0.060]
Obs.	20,971	10,508	12,877	316,920			

SEIEP = Secondary Education Instructional Equipment Program, TRSBP = Typhoon-Resistant School Building Program.

Notes: The sample includes individuals aged 9–12 years and 17–20 years in 1989. Standard errors in brackets. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.

Source: Minnesota Population Center. 2015. *2000 Integrated Public Use Microdata Series, International: Version 6.4*. Minneapolis: University of Minnesota.

of the age cohort in 1989 (9–12 years or 17–20 years), boys and girls from municipalities that received only the SEIEP assistance package had the lowest average level of educational attainment. This was followed in ascending order by those from municipalities that received both assistance packages, neither assistance package, and the TRSBP package only. The results may reflect differences in economic status of the municipalities. On the other hand, over time, the average educational attainment seems to have increased more in municipalities that received either the SEIEP package only or both packages when compared to municipalities that received either the TRSBP package or none at all. Examining the differences among age cohorts for each of the municipalities that received assistance from TRSBP only, SEIEP only, or both programs relative to those receiving no assistance provides the simple difference-in-differences estimates. For boys living in municipalities that received either instructional resources only (SEIEP) or both typhoon-resistant schools and instructional resources (Both), educational attainment increased by 0.32 years and 0.38 years, respectively. For girls living in municipalities that received both packages (Both), educational attainment increased by 0.36 years. The availability of either program alone did not have an impact on the educational attainment of girls.

Table 3. **Impacts of TRSBP and SEIEP on Educational Attainment**

	Males		
	(1)	**(2)**	**(3)**
TRSBP × Age (9–12 years) in 1989	−0.02	−0.02	−0.03
	[0.044]	[0.044]	[0.044]
SEIEP × Age (9–12 years) in 1989	0.23***	0.26***	0.25***
	[0.060]	[0.060]	[0.060]
Both × Age (9–12 years) in 1989	0.29***	0.31***	0.26***
	[0.054]	[0.054]	[0.055]
Water and sanitation × Age (9–12 years) in 1989			0.05**
			[0.021]
ADB–USAID × Age (9–12 years) in 1989			−0.17***
			[0.023]
Individual-level characteristics	No	Yes	Yes
Age dummies and municipality fixed effect	Yes	Yes	Yes
Constant	9.06***	8.45***	8.45***
	[0.017]	[0.048]	[0.048]
	Females		
	(1)	**(2)**	**(3)**
TRSBP × Age (9–12 years) in 1989	0.01	0.01	−0.02
	[0.044]	[0.044]	[0.044]
SEIEP × Age (9–12 years) in 1989	0.03	0.03	0
	[0.061]	[0.061]	[0.062]
Both × Age (9–12 years) in 1989	0.30***	0.32***	0.23***
	[0.056]	[0.056]	[0.056]
Water and sanitation × Age (9–12 years) in 1989			0.14***
			[0.021]
ADB–USAID × Age (9–12 years) in 1989			−0.20***
			[0.022]
Individual-level characteristics	No	Yes	Yes
Age dummies and municipality fixed effect	Yes	Yes	Yes
Constant	9.20***	7.52***	7.52***
	[0.016]	[0.033]	[0.033]

ADB = Asian Development Bank, SEIEP = Secondary Education Instructional Equipment Program, TRSBP = Typhoon-Resistant School Building Program, USAID = United States Agency for International Development.

Notes: Standard errors (in brackets) account for clustering in the municipality of residence in 1990. The base sample consists of children aged either 9–12 years or 17–20 years in 1989. These children were assessed again in 2000 when aged 20–23 years or 28–31 years. Each column estimates the interaction of TRSBP availability and the age dummy (9–12 years), the interaction of SEIEP availability and the age dummy (9–12 years), and the interaction of the indicator of both programs' availability and the age dummy (9–12 years). All specifications include single age dummies and the 1990 municipality of residence fixed effect. Individual-level characteristics include religion and ethnicity indicators. The sample includes individuals aged 9–12 years and 17–20 years in 1989. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.

Source: Minnesota Population Center. 2015. *2000 Integrated Public Use Microdata Series, International: Version 6.4*. Minneapolis: University of Minnesota.

Table 3 formally reports the estimates of the effects of access to typhoon-resistant schools, instructional equipment, or both components on the years of schooling of boys and girls (columns 1–3). Column (1) shows the most

parsimonious specification, including only age-cohort fixed effects and municipality fixed effects. Among boys, the availability of the instructional equipment program package in a municipality led to an average increase of 0.23 years of schooling, while the availability of both typhoon-resistant schools and instructional resources led to an average increase of 0.29 years of schooling. Among girls, the availability of both packages increased their educational attainment by an average of 0.30 years. Relative to the average educational attainment of boys and girls in the Philippines, which are relatively high compared with other Asian economies, these effects are equivalent to about a 3% increase in years of education for both boys and girls.

Column (2) suggests that these estimates are also generally robust to the inclusion of individual-level characteristics such as ethnicity and religion, as the estimates only slightly increased for both boys and girls. Column (3) accounts for the presence of other programs being implemented concurrently that also could have potentially impacted educational attainment. For boys, accounting for these concurrent programs led to an average increase of about 0.25 years and 0.26 years of education for those exposed to SEIEP only and to both programs, respectively. For girls, the availability of both programs leads to an average increase of 0.23 years of education, while the availability of either program alone does not seem to have had an effect.

Taken jointly, these results suggest that the presence of typhoon-resistant secondary schools alone is not enough to increase one's educational attainment. The availability of secure and adequate school facilities needs to be accompanied by appropriate instructional resources in order to significantly increase the educational attainment of both boys and girls. Although recent papers have focused on examining the effects of technology-related instructional resources (Angrist and Lavy 2002; Barrow, Markman, and Rouse 2009; and Beuermann et al. 2015), in general, the results of this study corroborate the importance of equipping classrooms with instructional resources to improve student outcomes. While there have been a limited number of studies that examine the importance of nontechnological instructional resources, Chingos and Whitehurst (2012) note that such instructional materials have a direct influence on both teacher effectiveness and student learning.

Now, what might explain the difference in patterns observed for boys and girls? The pattern of results for boys reflects the importance of instructional resources (or the quality of instruction), regardless of the presence of typhoon-resistant school infrastructure, in keeping teenage boys in secondary schools. On the other hand, the pattern observed for girls suggests the importance of school infrastructure, in addition to the instructional resources, in keeping teenage girls in secondary schools. The latter finding is consistent with studies that suggest the importance of the availability of an adequate water supply, sanitation facilities, and hygienic conditions on girls' education outcomes (Birdthistle et al. 2011, Burton 2013, Gius and Subramanian 2015, and Adams et al. 2009). Secondary school-aged girls and boys may be affected in different ways by inadequate schooling infrastructure,

Table 4. **Robustness Checks**

	Restrict to Localities in Typhoon Belt		With Municipality-Specific Linear Trend	
	Male (1)	**Female (2)**	**Male (3)**	**Female (4)**
TRSBP × Age (9–12 years) in 1989	0	0.01	−0.05	−0.05
	[0.04]	[0.04]	[0.04]	[0.04]
SEIEP × Age (9–12 years) in 1989	0.29***	0.04	0.23***	−0.03
	[0.06]	[0.06]	[0.06]	[0.06]
Both × Age (9–12 years) in 1989	0.30***	0.28***	0.24***	0.20***
	[0.05]	[0.05]	[0.05]	[0.06]
With controls	Yes	Yes	Yes	Yes
Constant	4.88***	5.02***	3.61***	3.44***
	[0.30]	[0.30]	[0.26]	[0.27]

ADB = Asian Development Bank, SEIEP = Secondary Education Instructional Equipment Program, TRSBP = Typhoon-Resistant School Building Program, USAID = United States Agency for International Development.

Note: Standard errors (in brackets) account for clustering in the municipality of residence in 1990. The dependent variable (education) is measured in years. Each column estimates the interaction of TRSBP availability and the age dummy (9–12 years), the interaction of SEIEP availability and the age dummy (9–12 years), and the interaction of the indicator of both programs' availability and the age dummy (9–12 years). All specifications include single age dummies, 1990 municipality of residence, religion, and ethnicity indicators, water and sanitation availability × Age (9–12 years), ADB–USAID × Age (9–12 years), and enrollment rate × Age. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.

Source: Minnesota Population Center. 2015. *2000 Integrated Public Use Microdata Series, International: Version 6.4*. Minneapolis: University of Minnesota.

particularly by an inadequate water supply or a lack of toilets or sanitation facilities. According to Adams et al. (2009), girls are disproportionately more affected than boys by the lack of physical infrastructure. This may be because parents are less likely to send their daughters to school when there is a lack of adequate, private, and secure sanitation facilities. Furthermore, the lack of appropriate facilities for menstrual hygiene can lead teenage girls to miss school during their menstruation period and possibly to drop out altogether. Thus, while instructional resources are crucial for teenage girls' learning and motivation, having secure and adequate physical infrastructure is also essential in keeping them in school.

B. Robustness and Specification Checks

Table 4 includes robustness checks for the results obtained in Table 3. The first two columns restrict the analysis to regions within the Philippines' typhoon belt. By restricting the analysis to these regions, municipalities have more or less a similar probability of being affected by a destructive typhoon and are more homogeneous in terms of socioeconomic status. As shown in columns (1) and (2), this leads to slightly higher coefficients. For boys, the availability of SEIEP leads to an average increase of 0.29 years of education, while the availability of both programs leads to an average

increase of 0.30 years of education. For girls, the availability of both programs leads to an average increase of 0.28 years of education. Columns (3) and (4) add a municipality-specific linear time trend to capture evolving, unobserved municipality characteristics that may have changed the level of schooling independent of the programs. In general, adding this only slightly decreases the coefficients while the patterns remain the same.

In Table 5, as a falsification test, I run the same specifications used in Table 3 with a sample of all postsecondary school-aged individuals (17–24-year olds) who would have had little or no exposure to the program packages. This table serves as a specification check as it aims to examine whether there are any preexisting trends in schooling outcomes in the same municipalities that later received the Japanese grant assistance. If educational attainment increased faster in municipalities that would later receive these program packages, even among young adults who would not have been exposed to these programs, then the estimates may be capturing the effects of other municipality trends that are correlated with the programs.

In general, for both boys and girls, the coefficients under TRSBP only and under both program packages are relatively small and not significant. On the other hand, the coefficients under SEIEP are relatively large and are particularly significant for girls. It may be that the estimate for SEIEP $\times$ Age (17–20 years) could be capturing some preexisting trends correlated with the allocation of the instructional resources program. However, since the effect of SEIEP for girls is small and not statistically significant when using the original sample, but becomes sizable and statistically significant when using the sample for the falsification test, it could be that there is also a timing issue. That is, teenage girls in relatively poorer municipalities may be more likely to fall behind in their schooling relative to peers in more affluent municipalities. It is also possible that these girls may have entered school at a later age.

To further examine the differing impacts on young boys and girls, Table 6 shows the interaction between the availability of each program package with age dummies ranging from 9–18 years. Those aged 19–20 years in 1989 are included in the control group. In general, the interactions of the availability of typhoon-resistant schools (TRSBP) with age dummies yield relatively small and insignificant coefficients, although some coefficients are larger than the others. These results are consistent with the patterns observed in Tables 3–5. The coefficients of the interaction of having both programs (Both) with each of the age dummies are also consistent with the results found earlier. For both boys and girls, coefficients are relatively large and statistically significant (ranging from 0.16 to 0.42) until about age 13–14 and then they fluctuate around 0 afterward. The interactions of the availability of instructional resources (SEIEP) with each of the age dummies also provide a clearer picture of the patterns observed earlier. For boys, coefficients are relatively large and statistically significant until about age 12 and then they become smaller and are not statistically significant. For girls, the coefficients are relatively

Table 5. **Impact of TRSBP and SEIEP on Educational Attainment: Falsification Test Sample**

	Males		
	(1)	**(2)**	**(3)**
TRSBP × Age (17–20 years) in 1989	−0.03	−0.03	−0.04
	[0.05]	[0.05]	[0.05]
SEIEP × Age (17–20 years) in 1989	0.11*	0.1	0.09
	[0.07]	[0.07]	[0.07]
Both × Age (17–20 years) in 1989	−0.03	−0.03	−0.05
	[0.06]	[0.06]	[0.06]
Water and sanitation × Age (17–20 years) in 1989			0.04*
			[0.02]
ADB–USAID × Age (17–20 years) in 1989			−0.03
			[0.02]
Individual-level characteristics	No	Yes	Yes
Constant	8.66***	7.17***	7.18***
	[0.02]	[0.04]	[0.04]
	Females		
	(1)	**(2)**	**(3)**
TRSBP × Age (17–20 years) in 1989	0.01	0	−0.01
	[0.05]	[0.05]	[0.05]
SEIEP × Age (17–20 years) in 1989	0.18***	0.19***	0.18***
	[0.07]	[0.07]	[0.07]
Both × Age (17–20 years) in 1989	−0.03	−0.03	−0.05
	[0.06]	[0.06]	[0.06]
Water and sanitation × Age (17–20 years) in 1989			0.06**
			[0.02]
ADB–USAID × Age (17–20 years) in 1989			−0.04
			[0.02]
Individual-level characteristics	No	Yes	Yes
Constant	8.93***	7.15***	7.15***
	[0.02]	[0.04]	[0.04]

ADB = Asian Development Bank, SEIEP = Secondary Education Instructional Equipment Program, TRSBP = Typhoon-Resistant School Building Program, USAID = United States Agency for International Development.

Notes: Standard errors (in brackets) account for clustering in the municipality of residence in 1990. The base sample consists of children aged either 17–20 years or 21–24 years in 1989. These children were assessed again in 2000 when aged 28–31 years or 22–35 years. The dependent variable (education) is measured in years. Each column estimates the interaction of TRSBP availability and the age dummy (17–20 years), the interaction of SEIEP availability and the age dummy (17–20 years), and the interaction of the indicator of both programs' availability and the age dummy (17–20 years). All specifications include single age dummy and the 1990 municipality of residence dummy. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.

Source: Minnesota Population Center. 2015. *2000 Integrated Public Use Microdata Series, International: Version 6.4*. Minneapolis: University of Minnesota.

small and not significant except for some large and statistically significant effects at ages 14 and 17.

The large coefficient (0.34) for the interaction between the availability of instructional equipment (SEIEP) and age 17 may suggest three things. First, it is

Table 6. **Coefficients of the Interaction of Each Program Package with Age in 1989**

	Male	Female		Male	Female		Male	Female
TRSBP_9	−0.02	0.03	SEIEP_9	0.26***	0.15	BOTH_9	0.22**	0.42***
	[0.07]	[0.07]		[0.10]	[0.10]		[0.09]	[0.09]
TRSBP_10	−0.11	−0.03	SEIEP_10	0.27***	0.03	BOTH_10	0.35***	0.28***
	[0.08]	[0.07]		[0.10]	[0.10]		[0.09]	[0.09]
TRSBP_11	0.01	0.08	SEIEP_11	0.30***	−0.07	BOTH_11	0.19**	0.28***
	[0.08]	[0.08]		[0.10]	[0.11]		[0.09]	[0.10]
TRSBP_12	−0.01	−0.05	SEIEP_12	0.27**	0.00	BOTH_12	0.18*	0.16*
	[0.08]	[0.08]		[0.11]	[0.11]		[0.10]	[0.10]
TRSBP_13	−0.09	−0.09	SEIEP_13	0.10	0.01	BOTH_13	0.27***	0.21**
	[0.08]	[0.08]		[0.10]	[0.11]		[0.10]	[0.10]
TRSBP_14	−0.12	0.02	SEIEP_14	−0.03	0.26**	BOTH_14	0.18*	0.00
	[0.08]	[0.08]		[0.11]	[0.11]		[0.10]	[0.10]
TRSBP_15	−0.02	0.09	SEIEP_15	0.03	0.02	BOTH_15	−0.03	0.07
	[0.08]	[0.08]		[0.11]	[0.11]		[0.10]	[0.10]
TRSBP_16	−0.01	0.01	SEIEP_16	−0.03	0.03	BOTH_16	0.18*	0.00
	[0.08]	[0.08]		[0.11]	[0.11]		[0.10]	[0.10]
TRSBP_17	0.01	0.01	SEIEP_17	0.00	0.34***	BOTH_17	0.04	0.13
	[0.08]	[0.08]		[0.11]	[0.11]		[0.10]	[0.10]
TRSBP_18	−0.01	0.09	SEIEP_18	0.11	−0.17	BOTH_18	−0.17*	0.08
	[0.08]	[0.08]		[0.11]	[0.11]		[0.10]	[0.10]
						Constant	7.30***	7.47***
							[0.03]	[0.03]

SEIEP = Secondary Education Instructional Equipment Program, TRSBP = Typhoon-Resistant School Building Program.

Notes: The sample includes individuals aged 9–20 years. Standard errors (in brackets) account for clustering in the municipality of residence in 1990. The dependent variable (education) is measured in years. Each column estimates the interaction of TRSBP availability with each of the age dummies 9–18 years (age 19–20 as base group), the interaction of SEIEP availability with each of the age dummies 9–18 years (age 19–20 as base group), and the interaction of the indicator of both programs' availability with each of the age dummies 9–18 years (age 19–20 as base group). All specifications include single age dummies and 1990 municipality of residence. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.

Source: Minnesota Population Center. 2015. *2000 Integrated Public Use Microdata Series, International: Version 6.4*. Minneapolis: University of Minnesota.

possible that even children of this age in 1989 may be benefiting from the program because in poorer municipalities, these children might still be in secondary school due to a delayed entrance into school. Second, school officials in these municipalities may have also prioritized the enrollment of these students considered to be at the margin of eligibility. Unfortunately, I have insufficient data to support either of these possible explanations. But to the extent that some of the girls in the control cohorts (aged 17–20 years in 1989) have benefited from SEIEP, then the results shown earlier may be an underestimation of the true effects of the program. A third possible explanation is that there could be other municipality trends that are correlated with the SEIEP program but not captured by the specification. However, such trends do not really correspond to the null results observed in the interaction of SEIEP with younger age dummies (aged 9–12 years in 1989) as shown in Table 3. To the extent that girls in the control cohorts (aged 17–20 years in 1989) have

benefited from other programs that might be correlated with the allocation of SEIEP assistance packages, then this could also lead to the underestimation of the true effects of the program.

VI. Conclusion and Policy Implications

This study evaluates the effects on educational attainment of typhoon-resistant schools and instructional equipment at the municipal level in the Philippines. For boys, the presence of typhoon-resistant schools equipped with instructional equipment led to an average increase of about 0.26–0.31 years of education, while the presence of instructional resources alone led to an average increase of 0.23–0.26 years of education. For girls, the availability of both components led to an average increase of 0.23–0.32 years of education, while the availability of either component alone does not seem to have had an effect. The estimates are generally robust when including individual-level characteristics, accounting for other central government programs being implemented concurrently, restricting to municipalities in the Philippines' typhoon belt, and accounting for municipality-specific trends.

The findings suggest the importance of not only expanding access to secondary schooling through increased availability of schools and classrooms, but also of improving the quality of learning through the availability of school resources that aid in secondary school students' learning in developing economies. For disaster-prone countries such as the Philippines, innovative solutions such as typhoon-resistant schools may not suffice. It may also be necessary to equip these schools with the needed instructional materials for critical subjects such as mathematics and science to reduce the likelihood of dropping out among secondary school children. This suggests that for governments to increase human capital, they need to pay equal, if not more, attention to increasing the quality of educational tools as is paid to improving the quantity and quality of educational infrastructure.

Furthermore, the findings of this study suggest there is a need to account for the fact that teenage boys and girls may be affected differently by the challenges of inadequate physical infrastructure and instructional resources. In order to improve the educational attainment of boys, the findings point to the importance of improving access to quality instructional resources. On the other hand, in order to improve the educational attainment of girls, the results indicate the need to invest not only in basic instructional materials for teaching high school subjects, but also in secure, disaster-resistant physical infrastructure with adequate access to water, power, sanitation, and sewerage facilities.

This study has focused on investigating the impact of typhoon-resistant schools and instructional resources on educational attainment. It remains an open question whether the observed increases in educational attainment had a broader impact on other measures of human capital development and labor market outcomes. Investigating these effects will be the subject of future study.

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