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Rapid Productivity Growth in Asia: Internal and External Financing

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Abstract

Developing Asia has achieved remarkable economic growth in the last several decades but faces challenges moving from middle-income to high-income status. This paper examines the macroeconomic impacts of future productivity growth in developing Asia on the region and the world, focusing on the responses of private investment. We consider five scenarios of productivity growth driven by catch-up mechanism, with our results showing that Asia's transition to high-income status requires continued rapid productivity growth and massive private investment. The increase in investment would significantly raise real interest rates domestically, resulting in international capital flows. Quantitatively, increased investment would be financed mainly through domestic saving, but international capital markets would also play a critical role. Productivity growth in one region generates spillover effects in others through two channels, namely international trade and capital flows. Spillover effects tend to be modestly negative in the medium term because capital flows would increase interest rates, but positive in the long term because regions with rising productivity would increase imports from other regions. Thus, competition among Asian economies and with other developing regions is not a zero-sum game as they benefit from each other in the long term. Continuous improvement in policies, institutions, and governance in developing Asia is required to achieve rapid productivity growth and to reduce the risks among economies in attracting international capital flows. Additionally, we examine two climate change scenarios and show that climate change will negatively impact productive investment and economic growth both in developing Asia and globally, as it will reduce productivity.

Keywords

catch-up, macroeconomic effects, middle-income trap, population growth, global model, agriculture, manufacturing, services, G-Cubed

JEL Classification

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Rapid Productivity Growth in Asia: Internal and External Financing

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1. INTRODUCTION

Developing Asia has achieved remarkable economic growth in the last several decades, which has raised almost all low-income economies in the region to middle-income status and lifted millions of people out of poverty. Most developing economies in the region have experienced sustained periods of markedly higher per capita GDP growth than advanced economies (Table 1), and this catch-up process has reduced the income gap between developing Asia and high-income economies through productivity growth, structural transformation, and capital accumulation.

Table 1: Real Per Capita GDP Growth in Developing Asia (%), 1990–2019

Region	Economy	1990–1999	2000–2009	2010–2019
East Asia	People's Republic of China	9.44	9.90	6.74
	Mongolia	−1.44	5.50	5.77
Southeast Asia	Cambodia	−1.97	6.38	5.72
	Indonesia	2.07	3.75	4.17
	Lao PDR	3.73	5.35	5.62
	Malaysia	4.05	1.93	3.58
	Myanmar	5.08	11.33	5.97
	Philippines	0.34	2.52	4.50
	Thailand	2.97	3.44	2.69
	Viet Nam	5.83	5.56	5.51
South Asia	Bangladesh	2.68	4.09	5.44
	India	3.70	4.85	5.14
	Nepal	2.47	2.72	4.31
	Pakistan	0.94	2.35	2.63
	Sri Lanka	4.18	3.85	4.40
Advanced economies	United States	2.09	0.72	1.67
	European Union	0.97	1.37	1.20
	Japan	0.84	0.08	1.00
	Republic of Korea	5.92	3.89	2.45
	Singapore	3.80	2.44	2.58
	Hong Kong, China	1.87	3.26	1.67
	Taipei,China	4.71	0.83	1.29

Source: The World Bank World Development Indicators for all economies except Taipei,China; Feenstra, Inklaar, and Timmer (2021) for Taipei,China.

Asian developing economies aim to move from middle-income to high-income status, with clear targets being set on the policy agendas of some economies. However, international evidence, especially the Latin American experience, suggests that it is much harder for middle-income economies to attain high-income status than it is to transition from low-income to middle-income status, a challenge that is well known as the middle-income trap (Gill, Kharas, and Bhattasali 2007; Glawe and Wagner 2016; Agénor 2017). The Asian experience reinforces the challenge, and only American Samoa and the Republic of Korea have successfully transitioned from middle-income to high-income status in the last three decades.[1]

[1] The World Bank's definitions of income status by gross national income per capita for the 2024 fiscal year in USD are: low-income: less than or equal to $1,135; lower-middle income: $1,136 to $4,465; upper-middle income: $4,466 to $13,845, and high-income: greater than $13,846. Brunei Darussalam; Hong Kong, China; Japan; Singapore; and Taipei, China have been classified as high-income economies since at least 1990.BI

An important aspect of economic growth in Asia is its international linkages with advanced economies. Most developing economies in the region, despite heterogeneity, depend heavily on international trade and foreign direct investment. The transition towards high-income status requires further improvement in productivity and massive capital investment; however, developing economies often face challenges in securing sufficient investment funds due to limited domestic resources, underdeveloped financial systems, weak institutions and governance, and inadequate infrastructure.

This paper explores long-term scenarios of productivity growth in Asia over the next several decades. If developing Asia implements better policies, improves institutions and governance, and fosters stronger geopolitical relationships with advanced economies, their catching up of the productivity frontier can be even faster than their past experiences. In response to productivity growth, firms make endogenous decisions around input accumulation or reallocation of resources within and across economies, and households also respond by changing their consumption and saving. This paper does not model specific drivers of productivity growth; instead, it examines the macroeconomic implications of hypothetical productivity catch-up scenarios for those economies experiencing productivity growth and the global economy more broadly.[2] We focus in particular on private investment responses, which can potentially be jointly financed domestically and externally.

This paper considers five productivity catch-up scenarios: (1) individual catch-up, where a single region in developing Asia experiences faster catch-up rates than the baseline; (2) lower-middle-income group catch-up, where lower-middle-income economies in Asia (India, Viet Nam, the Philippines, and other South Asian economies) experience faster catch-up rates; (3) upper-middle-income group catch-up, where upper-middle-income economies in Asia (the PRC, Indonesia, Malaysia, and Thailand) experience faster catch-up rates; (4) developing Asia catch-up, where all middle-income economies in Asia experience faster catch-up rates; and (5) developing Asia and other developing regions in the world, where all experience faster catch-up rates. Our results show that if an Asian developing economy experiences fast productivity growth alone, investment increases rapidly, resulting in higher output, the real interest rate rises domestically, and capital flows in from other regions, which also raises the real interest rates in other regions. As output rises, households increase their consumption and also how much they save. Increased investment is financed jointly by domestic saving and international borrowing, resulting in current account deficits. If multiple Asian economies experience fast productivity growth collectively, the real interest rates increase more than in the case of individual catch-up; thus, investment and output in each region are lower in collective growth scenarios than in individual catch-up cases. Although developing regions compete for external investment in collective catch-up scenarios, it is not a zero-sum game between regions. Compared to individual catch-up scenarios, the reductions in investment and output in collective catch-up scenarios are only modest, while the increases in real interest rates are moderate and in some cases strong. The regions that experience productivity growth increase investment and consumption, which augments the demand for imports of intermediate and final goods and hence generates spillover effects on other regions.

In addition to the productivity catch-up scenarios, we also incorporate the effects of climate change scenarios on economic growth based on two Shared Socioeconomic Pathway (SSP) scenarios: SSP2-4.5 and SSP5-8.5. SSP2-4.5 represents a scenario where social, economic, and technological trends do not shift markedly from historical

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[2] Many empirical studies examine productivity catch-up across economies (Barro and Sala-i Martin 1992; Barro 2015; Johnson and Papageorgiou 2020).

patterns, while SSP5-8.5 represents the worst SSP scenario in which the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource- and energy-intensive lifestyles around the world. The impacts of climate change are broadly opposite to those of productivity growth because climate change is expected to reduce both labor productivity and total factor productivity (TFP).

The rest of the paper is organized as follows. Section 2 introduces the G-Cubed model, and Section 3 presents the approach of generating a baseline and the data used in the baseline. Section 4 discusses different scenarios of productivity growth and climate change, while Section 5 presents the baseline and the impacts on key macroeconomic variables in various scenarios. Section 6 discusses sources of investment financing, drivers of productivity growth, and some caveats on our estimates of climate impacts. Section 7 concludes with some policy implications.

2. THE G-CUBED MODEL

Liu and McKibbin (2022) develop a variant of the G-Cubed model of McKibbin and Wilcoxen (1999, 2013), which disaggregates the global economy into 18 regions, with a particular focus on Asia. This geographic disaggregation makes the model well suited to analyzing the productivity catch-up of economies in the Asian region. Table 2 lists all the regions contained in the model, with some corresponding to individual economies. The high-income economies include the United States, Japan, western Europe, Australia, the Republic of Korea, and the rest of the advanced economies. The regions classified as upper-middle-income are the PRC, Indonesia, Malaysia, and Thailand, while the lower-middle-income economies include India, the Philippines, and Viet Nam. The rest of Asia appears in the model but is aggregated.

Table 2: G-Cubed Regions

Groups	Codes	Regions	Income Status
Advanced Economies	USA	United States	High
	JPN	Japan	High
	EUW	Western Europe	High
	AUS	Australia	High
	KOR	Republic of Korea	High
	ADV	Rest of Advanced Economies	High
Developing Asia	CHN	PRC	Upper-middle
	IDN	Indonesia	Upper-middle
	THA	Thailand	Upper-middle
	MYS	Malaysia	Upper-middle
	IND	India	Lower-middle
	PHL	Philippines	Lower-middle
	VNM	Viet Nam	Lower-middle
	ROA	Rest of Asia	Mixed
Other Developing Regions	LAM	Latin America	Mainly middle
	AFR	Sub-Saharan Africa	Mainly low
	MEN	Middle East and North Africa	Mainly middle
	ROW	Rest of the World	Mainly middle

Notes: (1) Income classifications are based on the World Bank definitions of income status by GNI per capita. The 2024 fiscal year definitions in USD are: Low-income: ≤ 1,135; Lower-middle income: 1,136−4,465; Upper-middle income: 4,466−13, 845; High-income: > 13,846. (2) ADV: Canada and New Zealand; ROA: Mainly South Asia (excluding India), mixed with Hong Kong, China; Taipei,China; Singapore; and Mongolia; ROW: Mainly Eastern Europe (including Russian Federation and Türkiye) and Central Asia.

The model also contains a useful sectoral breakdown for the analysis as each sector has different capital-to-labor ratios that are important for their role in catching up with the sectoral frontier. The model used for this study contains six sectors, as presented in Table 3. The sectors are interconnected through input-output linkages, with the data being sourced from the GTAP 10 database (Aguiar et al. 2019). The 65 sectors in the GTAP database are mapped onto the six sectors in the G-Cubed model.

Table 3: G-Cubed Sectors

Groups	Number	Sector
Primary Sectors	1	Energy
	2	Mining
	3	Agriculture
Manufacturing Sectors	4	Durable Manufacturing
	5	Nondurable Manufacturing
Service Sector	6	Services

The G-Cubed model incorporates standard features of large-scale macroeconomic models, and below, we highlight some key elements that drive short-run dynamics and long-run equilibrium in the model.

Households: Households make intertemporal decisions on consumption and saving to maximize expected lifetime utility, subject to an intertemporal budget constraint. Households are heterogeneous, with one group making decisions based on forward-looking expectations and the other subject to binding liquidity constraints.

Firms: Firms are modeled separately within each sector in a competitive market environment. In each sector, firms make decisions on investment and employment to maximize their expected market value. Firms are also heterogeneous, with one group making decisions based on forward-looking expectations and the other following simple rules of thumb.

Labor Markets: The labor market features sticky nominal wages that adjust over time, with the adjustment mechanisms being specific to each economy, given their different labor contracting laws and regulations. The labor market clears with firms hiring until the marginal product of labor equals the real wage in each sector, with excess labor joining unemployed workers. In turn, nominal wages adjust to clear the labor market in the long run, while short-term unemployment rises or falls in response to aggregate demand and supply shocks.

Governments: Governments collect taxes and allocate spending, subject to an intertemporal budget constraint. In the model used for this paper, government spending is exogenous, while government deficit is endogenous. Government deficits accumulate into government debt over time. The fiscal rule imposing fiscal sustainability is a lump sum tax on households that equals changes in interest payments on government debt, which implies that fiscal deficits can permanently change but the debt-to-GDP ratio eventually stabilizes at a new level.

Central Banks: Central banks set short-term nominal interest rates to target their macroeconomic mandates, such as inflation, unemployment, and the exchange rate. Long-run inflation rates are anchored while short-term fluctuations are managed through monetary policy, which follows the Henderson–McKibbin–Taylor monetary rule (Henderson and McKibbin 1993; Taylor 1993).

Balance of Payments: Economies are linked through international trade and capital flows. An intertemporal budget constraint also applies to economies, so current account deficits accumulate into foreign debt over time. Asset markets are perfectly integrated across regions, allowing for free capital mobility. The uncovered interest rate parity condition holds, where the differential in risk- adjusted nominal interest rates across regions equals the expected rate of change in the nominal exchange rate. Real interest rates adjust endogenously to equilibrate global saving and investment, leading to consistency across national intertemporal budget constraints and market-clearing conditions.

3. BASELINE

The model is solved from 2018, with forward-looking variables adjusted so that the model solution for 2018 replicates the data for that year. To generate a baseline for the future, key inputs include exogenous projections of age-specific population growth and sectoral labor-augmenting productivity growth by economy. The dynamics of endogenous variables, such as national and sectoral output, are driven by the growth of the labor force and productivity.

In each region, it is assumed that individuals follow a hump-shaped age productivity profile that is specific to each economy or region. At any given time, the aggregate effective labor supply is calculated as the sum, across all age cohorts, of age-specific productivity weighted by the size of each cohort. Thus, the aggregate effective labor supply can change over time with alterations in the age structure, which is important in the current context of global population ageing.

In addition, we introduce sector-specific labor-augmenting productivity growth, which varies across sectors but remains independent of age, and within each sector of every region, all workers experience the same productivity growth regardless of age. The projection of labor-augmenting productivity growth by sector and region follows a catch-up mechanism, as outlined at the end of this section.

3.1 Population

Population data are sourced from the United Nations World Population Prospects 2024 (the median variant) database, which contains annual data on population projections by age (0, 1, 2, ..., 99, 100+) up to 2,100 for 237 economies. We aggregate age-specific population data from these 237 economies to G-Cubed regions. Table 4 presents the population share for each region of the global population every decade from 2020 to 2050. Advanced economies are experiencing steady declines in their shares of the global population, and among developing regions, the population share of the People's Republic of China (PRC) is shrinking substantially due to dramatic declines in fertility. India is maintaining a stable population share, thereby reinforcing its demographic importance; however, Southeast Asia and Latin America are exhibiting mixed trends, with some economies experiencing slight declines while others remain stable. Africa stands out as the key driver of global population growth, with its share rising significantly.

Table 4: Population Share by Region (%)

Region	2020	2030	2040	2050
USA	4.30	4.15	4.03	3.94
JPN	1.60	1.40	1.22	1.09
EUW	5.55	5.17	4.80	4.49
AUS	0.33	0.33	0.33	0.34
KOR	0.66	0.60	0.53	0.47
ADV	0.55	0.55	0.54	0.53
CHN	18.08	16.32	14.63	13.04
IDN	3.48	3.45	3.40	3.32
THA	0.91	0.83	0.76	0.69
MYS	0.43	0.44	0.45	0.46
IND	17.78	17.80	17.68	17.38
PHL	1.42	1.42	1.41	1.39
VNM	1.24	1.22	1.18	1.14
ROA	8.10	8.42	8.78	9.10
LAM	8.19	8.02	7.81	7.55
AFR	14.84	17.36	19.94	22.54
MEN	6.09	6.58	6.92	7.23
ROW	6.43	5.96	5.59	5.32

Table 5 presents the age structure of each region from 2020 to 2050, as represented by the share of children (younger than 15 years old) in column Y, that of the working-age population (15–64 years old) in column W, and the proportion of the elderly (above 65 years old) in column E. The global age structure is shifting dramatically, with advanced economies ageing rapidly, while among developing regions, the PRC and much of Southeast Asia are also experiencing significant ageing. In contrast, South Asia and Africa continue to sustain a relatively young workforce, positioning them as key drivers of global labor force growth in the coming decades.

Table 5: Age Structure by Region (%)

	2020			2030			2040			2050		
Region	Y	W	E	Y	W	E	Y	W	E	Y	W	E
USA	18.39	65.54	16.07	16.26	63.37	20.37	15.94	62.03	22.04	15.91	60.98	23.11
JPN	12.22	58.86	28.92	10.39	58.47	31.14	10.42	54.23	35.35	11.25	51.27	37.48
EUW	15.42	64.02	20.56	13.73	61.83	24.44	13.07	58.79	28.14	13.54	56.63	29.83
AUS	18.56	65.10	16.34	16.88	63.29	19.82	15.86	61.84	22.30	15.71	60.44	23.85
KOR	12.11	72.06	15.82	8.43	66.50	25.06	7.73	58.44	33.83	7.83	52.49	39.68
ADV	16.24	66.05	17.71	14.65	63.15	22.20	13.87	61.91	24.22	13.66	60.86	25.48
CHN	17.95	69.40	12.65	12.14	69.52	18.34	9.38	64.01	26.62	9.94	59.14	30.92
IDN	25.83	67.56	6.61	22.43	68.61	8.97	20.49	67.39	12.12	19.18	65.68	15.14
THA	16.17	70.93	12.90	12.88	67.71	19.41	11.81	62.62	25.57	11.51	58.92	29.57
MYS	23.96	69.31	6.72	18.98	71.49	9.53	17.03	70.57	12.40	16.16	67.02	16.82
IND	26.35	67.24	6.42	22.39	69.06	8.56	19.93	68.87	11.19	17.79	67.53	14.68
PHL	30.68	64.59	4.73	23.83	69.33	6.84	21.17	70.03	8.80	19.62	69.22	11.15
VNM	24.39	68.04	7.57	19.95	68.26	11.79	17.58	66.67	15.75	16.96	63.04	20.01
ROA	31.50	62.54	5.95	28.77	63.75	7.48	26.26	64.78	8.95	24.06	65.11	10.83
LAM	23.90	67.27	8.83	20.38	67.76	11.86	18.11	66.69	15.19	16.59	64.52	18.89
AFR	41.97	54.94	3.08	38.70	57.85	3.44	35.38	60.61	4.01	32.08	63.01	4.92
MEN	30.47	64.38	5.15	26.56	66.68	6.76	24.01	67.03	8.97	22.45	65.60	11.94
ROW	20.42	66.28	13.30	18.40	65.22	16.39	16.78	64.72	18.50	17.30	61.33	21.37

Notes: Y denotes youth (younger than 15 years old); W denotes the working-age population (15–64); and E denotes the elderly (65 years and older).

3.2 Age-Income Profile

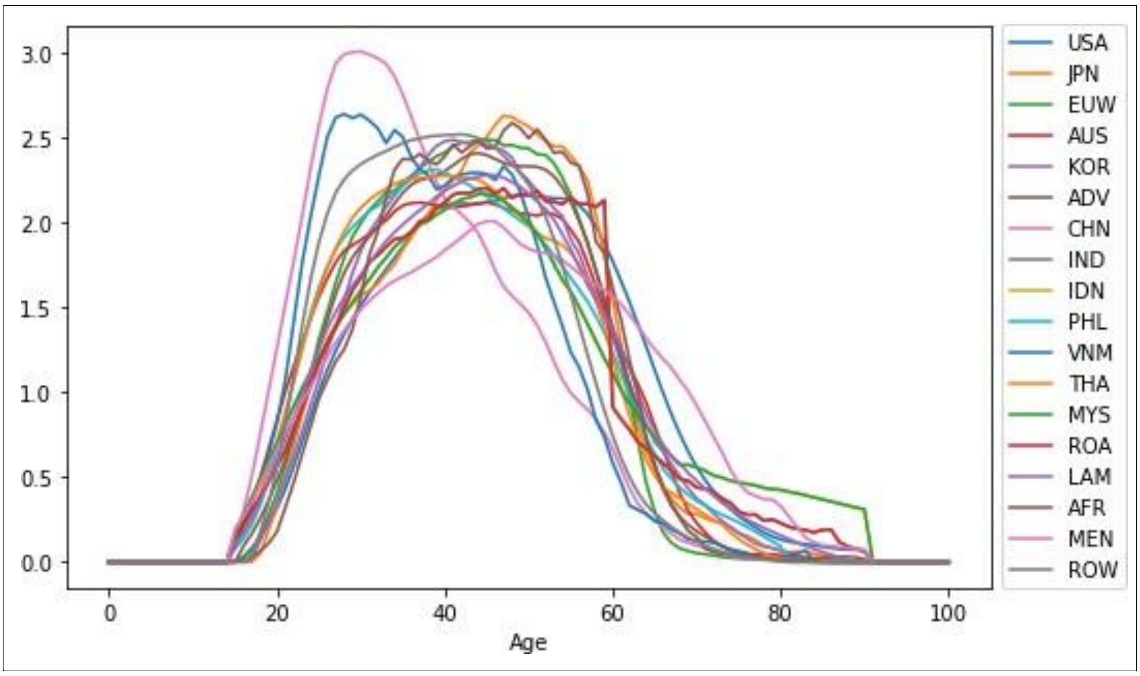
The National Transfer Account (NTA) database provides age-specific labor income data for about 70 economies, including 15 in Asia, for various years spanning from 2002 to 2019. We assume that age-income profiles will remain unchanged in the future. To map age-income profiles from NTA regions to G-Cubed regions, we use data from the largest economy, with data available in each region being representative of that region. This approach is supported by the strong similarity of age-income profiles among several large economies within each region. Table 6 presents the correspondence between NTA and G-Cubed regions. Germany represents EUW as the region's largest economy, with age-income profiles closely resembling those of France, Italy, and the United Kingdom. Brazil is chosen to represent Latin America, as it is the largest economy in the region, and its age-income profile is similar to that of several large economies such as Mexico, Argentina, Chile, and Colombia. South Africa represents Sub-Saharan Africa, as it is the largest economy in the region, while Nigeria, the second-largest economy, has a comparable age-income profile. For economies missing from the NTA database, we use Thailand for Malaysia due to their economic similarities, India for ROA as South Asian economies dominate the region, Türkiye for MENA, and the Russian Federation for ROW, given that ROW primarily comprises eastern Europe and central Asia.

Table 6: Economy Mapping Between NTA Database and G-Cubed

G-Cubed Region	NTA Economy
USA	United States
JPN	Japan
EUW	Germany
AUS	Australia
KOR	Republic of Korea
ADV	Canada
CHN	PRC
IDN	Indonesia
THA	Thailand
MYS	Malaysia
IND	India
PHL	Philippines
VNM	Viet Nam
ROA	India
LAM	Brazil
AFR	South Africa
MEN	Türkiye
ROW	Russian Federation

As income is measured in local currencies for different years across economies, we normalize the age-income distribution in each region by its lifetime average to enable cross-economy comparison. For the model input, we use these normalized age-income profiles and calculate the growth rates in aggregate labor productivity driven by changes in age structure. Any heterogeneity in regional average income levels has no impact on the results, which supports the above approach of representing age-income profiles across regions where data are missing. Figure 1 presents the age-income profiles for all regions after normalization, showing a strong hump-shaped pattern over the life cycle, with most regions exhibiting similar peak ages and distribution shapes.

Figure 1: Global Age-Income Profile



3.3 Sectoral Productivity

For labor-augmenting productivity, we use a catch-up model in which sectoral productivity in each region converges toward the corresponding sector in the frontier region. The process is driven by three components: productivity growth in the frontier region, initial productivity levels across sectors and regions, and catch-up rates.

We take the United States as the frontier region unless otherwise specified. According to the US Congressional Budget Office (US CBO 2023), US labor productivity is projected to grow at 1.4% annually over the next three decades; therefore, we assume that all sectors in the United States will grow at a constant rate of 1.4% every year in the future.

The initial productivity levels by sector are calculated based on the 2023 Groningen productivity database, which provides sectoral labor productivity data for 12 sectors across 84 economies in 2017, measured in local currency. Sectoral productivity is measured by value added per worker in each sector, and we map those economies and sectors to the G-Cubed model. The database also provides market exchange rates and sector-level purchasing power parity for cross-economy comparison. We convert local currency to US dollars using market exchange rates for more tradable sectors (mining, agriculture, manufacturing) and purchasing power parity for less tradable ones (utilities and services). The rationale for this approach is provided in the Appendix.

Table 7: Sector Mapping Between Groningen Database and G-Cubed Model

Groningen Sectors	G-Cubed Sectors
Agriculture	Agriculture
Mining	Mining
Manufacturing	Manufacturing
Utilities	Energy
Construction	Services
Trade	Services
Transport	Services
Business	Services
Finance	Services
Real estate	Services
Government	Services
Other services	Services

Notes: Utilities refer to electricity, gas, steam, and air conditioning supply; water supply; sewerage, waste management, and remediation activities.

We normalize initial productivity levels in all sectors of the United States to 100, assuming that the US economic structure remains stable on a balanced growth path. We then calculate relative productivity levels by sector for all other regions. Table 8 presents relative productivity levels by sector and region. The United States is the frontier in all sectors, except for Australia, which outperforms it in mining and agriculture. Developing Asia is far behind the frontier in the manufacturing sector and even more so in agriculture; however, their productivity gaps in less tradable sectors (utilities and services) are much smaller. Other developing regions have similar productivity gaps to those in manufacturing and agriculture in developing Asia; however, they have, on average, relatively higher productivity in the mining sector because mining productivity depends greatly on the abundance of mineral resources, and those regions are more resource-rich than developing Asia.

Table 8: Sectoral Productivity Levels in 2017

Regions	Energy	Mining	Agriculture	Manufacturing	Services
USA	100.00	100.00	100.00	100.00	100.00
JPN	48.22	14.47	26.44	59.03	74.72
EUW	25.69	89.57	50.17	56.82	97.21
AUS	31.64	123.87	126.19	52.59	82.38
KOR	84.96	21.88	27.21	55.71	97.12
ADV	85.04	87.15	93.48	55.88	84.27
CHN	54.06	10.76	5.45	12.85	60.29
IDN	25.39	13.35	4.22	6.88	78.06
THA	55.94	42.00	3.88	11.76	66.88
MYS	94.84	70.03	20.18	16.23	92.32
IND	47.19	5.26	2.52	3.97	41.49
PHL	25.29	3.11	3.53	10.07	22.02
VNM	30.54	18.89	1.90	2.14	43.32
ROA	37.86	8.99	2.39	8.12	47.03
LAM	35.33	38.95	10.91	18.11	49.40
AFR	58.82	12.59	1.86	3.39	26.53
MEN	46.28	54.07	5.33	10.23	49.38
ROW	32.77	23.32	7.36	13.30	80.24

In general, we assume that non-US regions catch up with the United States at the sectoral level, unless specific adjustments are made, which implies that regions with lower initial productivity levels than the United States are expected to grow faster. One of the adjustments is that Australia's mining and agricultural sectors are assumed to grow at 1.4% every year without catch-up, since they already have higher productivity than their US counterparts. The design of sector-specific catch-up rates is discussed in the next section.

4. SCENARIO DESIGN

This section discusses the design of two sets of scenarios, namely productivity growth and climate change, comprising five productivity and two climate scenarios, in addition to the baseline.

4.1 Productivity Scenarios

To design sensible scenarios of productivity growth, we distinguish catch-up rates between resource and nonresource sectors, taking into consideration the differences in natural endowments across sectors and regions. Productivity levels in resource sectors depend not only on labor and capital but also, more importantly, on natural endowments, including resource abundance (energy, minerals, and land) and both geographic and climate conditions (especially for agriculture). The pace at which resource sectors catch up with the frontier is inherently constrained by natural endowments.

Among advanced economies, Japan's productivity in agriculture is 26% of that of the United States, although Japan integrates advanced technology and machinery into agriculture. It is far from the frontier, but there is not much space for further improvement, given the constraint on land size. In addition to Japan, the Republic of Korea and western Europe are also constrained by natural endowments. Australia, meanwhile, enjoys abundant natural resources and already has higher productivity in the mining and agricultural sectors than the United States. The remaining advanced economies, Canada and New Zealand, also boast an abundancy of natural resources, and their productivity levels in resource sectors are close to those of the United States. Therefore, our model assumes no catch-up in resource sectors between non-US advanced economies and the United States, and with zero catch-up rates, the productivity in each resource sector grows at 1.4% every year in all advanced economies. For developing regions, most Asian economies are also significantly constrained by land size.

Even the PRC, despite its large size, has significantly less arable land than the United States. The productivity in agriculture in all developing Asian economies (except Malaysia) is about 5% or below relative to the United States. For developing Asia, it is reasonable to assume Japan rather than the United States as the productivity frontier for agriculture. In addition to land, developing Asian economies are not comparable to the United States in terms of the abundance of minerals. Other developing regions in the world have an abundance of natural endowments and are relatively highly productive in the energy and mining sectors, but much less so in agriculture.

In contrast to resource sectors, nonresource ones (manufacturing and services) depend more on labor and capital and have fewer constraints in terms of natural endowments, implying that the productivity of manufacturing and services can potentially reach the frontier level. We further distinguish between advanced and developing regions. Advanced economies share similar institutions and governance frameworks and have been closely integrated in the last several decades. Thus, we assume that advanced economies are all in their own steady states and do not catch up with the frontier in nonresource sectors (or, indeed, resource sectors). The productivity gaps can be attributed to fundamental heterogeneities in natural, geographic, cultural, and institutional differences. The productivity levels in services are already close to each other, and the productivity in manufacturing is also relatively high at about 50% in all other advanced economies. By contrast, the productivity levels in manufacturing are much lower in developing regions.

Thus, the design of productivity scenarios will focus on agriculture, manufacturing, and service sectors in developing Asia, with the United States as the frontier for manufacturing and services and Japan adopting the same role for agriculture. A wide range of scenarios is possible, depending on permutations of economies, sectors, and magnitudes of catch-up rates. We select a small set of representative scenarios designed to provide key insights. For catch-up rates, Barro and Sala-i Martin (1992) and Barro (2015) provide a benchmark that convergence in per capita GDP occurs at around 2% per year. Our productivity catch-up scenarios are outlined below.

1) **Baseline.** We calibrate the catch-up rates for developing Asia such that their GDP growth rates in the near future are broadly consistent with their historical performance in the last decade. More specifically, the catch-up rate is set at 2% for the PRC, while for India, Indonesia, and Viet Nam, the rate starts at 1% in 2025 and increases annually by 0.1% until reaching 2%. The rate is set at 1% for Thailand, Philippines, and the rest of Asia, given that it is a mixed region, and zero for Malaysia, while in other developing regions, the catch-up rate remains at zero.

2) **Asian individual catch-up.** If an Asian developing economy implements better policies, improves institutions and governance, and fosters stronger geopolitical relationships with advanced economies, these measures together increase the economy's catch-up rate by 1% in the agriculture, manufacturing, and service sectors.

3) **Asian upper-middle collective catch-up.** All upper-middle-income economies in Asia (the PRC, Indonesia, Thailand, and Malaysia) experience higher catch-up rates by 1% in the agriculture, manufacturing, and service sectors.

4) **Asian lower-middle collective catch-up.** All lower-middle-income economies in Asia (India, the Philippines, Viet Nam, and the rest of Asia) experience higher catch-up rates by 1% in the agriculture, manufacturing, and service sectors, but while the rates are the same as in the preceding scenario, the lower-middle-income group experiences faster productivity growth because their initial productivity levels are much lower, especially in the manufacturing and service sectors.

5) **Asian collective catch-up.** All Asian developing economies experience higher catch-up rates by 1% in the agriculture, manufacturing, and service sectors.

6) **Global collective catch-up.** Developing Asia and all other developing regions catch up with the productivity frontier, but developing Asia does so faster. Asian developing economies experience higher catch-up rates by 1% as mentioned above, while other developing regions experience catch-up rates of 0.5%.

4.2 Climate Scenarios

Roson and Sartori (2016) estimate a set of damage functions for chronic climate risks, including rises in sea level, agricultural productivity, heat-related labor productivity, and disease-related labor productivity. These functions characterize the relationships between temperature changes (relative to the historical average temperature between 1985 and 2005) and the impact channels for 140 regions included in the GTAP 9 database. We use their damage functions to project the impacts of temperature change on sectoral labor productivity and TFP.

The damage function for a rise in sea level provides the percentage change of land stock in response to a one-degree temperature increase by year and economy. The percentage loss in land is assumed to cause the same percentage loss in TFP in all sectors. The damage function for agricultural productivity provides the percentage change of agricultural TFP in response to a one-degree increase in temperature by economy. The damage function for heat-related labor productivity provides the percentage change in labor productivity in response to a one-degree increase in temperature by sector (agriculture, manufacturing, and service). The damage function for health-related labor productivity provides the percentage change in labor productivity in response to a one-degree increase in temperature due to changes in morbidity. It is assumed that productivity losses due to morbidity are temporary (not persistent across years). Bosello, Roson, and Tol (2006) estimate that the number of deaths is 12% of the years of life diseased due to a set of diseases, so we assume that labor productivity losses from mortality are 12% of those from morbidity. In contrast to temporary shocks from morbidity, mortality results in permanent productivity losses.

The World Bank (2024) provides projected annual temperatures until 2100 for all economies, sourced from the Coupled Model Intercomparison Project, a comprehensive ensemble of climate models. The temperature projections cover four Shared Socio-economic Pathway (SSP) scenarios, namely SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5, and we choose two for our simulations: SSP2-4.5 and SSP5-8.5. SSP2-4.5 represents a scenario where social, economic, and technological trends do not shift markedly from historical patterns, while SSP5-8.5 represents the worst SSP scenario in which the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource- and energy-intensive lifestyles.

We first aggregate economy-level temperatures from the World Bank climate database into 140 GTAP regions using population-weighted averages. Given the projected temperatures for 140 regions, we compute the damages from temperature changes (relative to the historical averages) by sector for 140 regions from 2018 to 2100 based on the damage functions. We further aggregate the climate damage from 140 regions to the 18 regions of G-Cubed. More specifically, we compute weighted percentage changes for land, agricultural productivity, and labor productivity, using land value, agricultural output value, and labor size as the respective weighting factors.

Our baseline projection is based on actual data from 2018, which we assume already reflects climate impacts up to that year. To construct a hypothetical no-climate-damage baseline for measuring the impacts of climate change, we need to remove the temperature shocks that have occurred above the 1985–2005 average temperatures. To achieve that, we introduce a counteracting shock that offsets the climate shock in 2024, which ensures that, when we simulate climate shocks starting in 2025, the new baseline is isolated from historical climate damage. For climate impacts beyond 2024, we calculate net climate shocks relative to the 2024 level; therefore, the future climate impacts relative to the no-climate-damage baseline include the cumulative effects of climate change up to 2024 plus additional changes from 2025 onward.

5. RESULTS

In this section, we first present GDP growth rates through 2050 in the baseline scenario, and then show the macroeconomic impacts of productivity growth across all productivity scenarios. We further discuss the heterogeneous impacts of productivity growth across regions and sectors, respectively, before finally presenting the macroeconomic impacts of the climate change scenarios.

5.1 Baseline Economic Growth

Table B1 presents annual growth rates in GDP and per capita GDP (in real terms) through to 2050 in the baseline, where per capita GDP is calculated by dividing GDP by population size. The average annual growth rates and cumulative growth rates in per capita GDP over the period of 2025–2050 are also presented.

Among advanced economies, per capita GDP in the United States continues to increase at about 1.4% (based on our productivity assumption), and other advanced regions grow at similar rates, although there is heterogeneity due to different economic interactions across economies, especially with developing regions. Developing Asia will experience stronger growth in per capita GDP because it is assumed that it will continue to catch up in terms of productivity with the United States, following its recent historical patterns. The catch-up effects are strong, given that its productivity levels still lag far behind the productivity frontier. The total growth in per capita GDP from 2025 to 2050 will range from 45% to about 100%.

The differences between GDP and per capita GDP growth are largely attributed to the change in age structure given the life cycle productivity profile. The United States experiences positive population growth, resulting in moderately higher growth in GDP than in per capita GDP. By contrast, Japan, the Republic of Korea, and Europe are expected to experience much lower GDP growth due to their population ageing. Among developing Asia economies, the PRC will also face adverse impacts of rapid population ageing, and Thailand is another case, albeit to a lesser extent. Other economies will continue to benefit from demographic dividends in the near future, but the dividends will diminish over time as population ageing gradually takes effect in those economies as well.

5.2 Macroeconomic Impacts of Productivity Growth

Tables 12–20 present the responses of key macroeconomic variables across all productivity scenarios, with the results reported as deviations from the baseline, expressed as percentage changes, percentages of GDP, or percentage points. Each table presents the results of a particular variable in all scenarios in two years, namely 2030 and 2050, representing the medium-run and long-run effects of productivity growth, respectively. The first row of each table represents different scenarios: (1) Own: productivity growth in each individual Asian economy; (2) Asia UM: productivity growth in upper-middle-income Asian economies (the PRC, Indonesia, Malaysia, Thailand); (3) Asia LM: productivity growth in lower-middle-income Asian economies (India, the Philippines, Viet Nam, and the rest of Asia); (4) Developing Asia: productivity growth across the whole of developing Asia; (5) Developing World:

productivity growth in developing Asia and all other developing regions. The Own column of each table represents the impacts of a economy's productivity growth on its own variable, where the variable is the subject of the table. For example, the CHN-2030 cell in Table B2 examining investment represents the impact of the PRC's productivity growth on its investment in 2030, and the IND-2030 cell represents the impact of India's productivity growth on the latter's investment in 2030.

Individual catch-up scenarios show that when a region experiences productivity growth, investment increases significantly in the region, ranging from 5% in the rest of Asia to 15% in Indonesia as a percentage of GDP above their respective baselines in 2030 (Table B2). These increases are substantial, bearing in mind that total investment typically accounts for 20%–30% of GDP in many developing economies in Asia. Such large investment responses require major resource reallocation and place significant pressure on financing mechanisms. In the long run, investment declines, ranging from 3% in the rest of Asia to 9% in Malaysia above their baselines, and this long-term decline occurs because productivity gains gradually diminish over time as developing Asia converges toward the global productivity frontier, thus reducing productivity gaps. Increased investment results in higher GDP, ranging from 5% in the rest of Asia to 12% in India above their respective baselines in 2030 (Table B3). In most cases, GDP continues t%–20% above their respective baselines in 2050.

The demand for investment increases the real interest rate in each catching-up region, with a rise of around one percentage point in 2030 in most cases (Table B4). This attracts capital flows into the region from all other regions, which also raises the real interest rates in other areas. As current and expected future output rises, households tend to increase consumption (Table B5); however, the increases in consumption in 2030 will generally be moderate in some cases, and even negative in a few. This is because households increase their saving substantially in response to a stronger demand for investment, ranging from 3% in the rest of Asia to 11% in Viet Nam in 2030 (Table B6). However, in the long run, consumption rises strongly as the demand for investment slows while output continues to grow over time. Public saving does not change much (Table B7). As government spending is exogenous, the change in government deficit is mainly driven by changes in tax revenues, which are quantitatively small in all the scenarios.

Increased private investment is jointly financed by higher levels of private saving (internal financing) and international borrowing (external financing), the latter being reflected in trade and current account deficits. Table B8 presents the change in private saving as a share of the change in private investment in each scenario. For example, in the case of the PRC's productivity growth, the increase in private saving accounts for 82% of the rise in private investment in 2030, indicating that 82% of the investment response to productivity growth is financed by domestic saving, with the rest being financed by external capital (given that the change in public saving is small).

A number of points from the table are worthy of comment. First, in the case of productivity growth in individual economies, the share of internal financing in 2030 ranges from 64% in Indonesia to 95% in Thailand, with a simple average of 80%, suggesting that, quantitatively, increased investment would be financed primarily through domestic saving. Such a pattern echoes the Feldstein–Horioka puzzle (Feldstein and Horioka 1980), which refers to a high correlation between domestic investment and saving despite capital mobility. Second, although internal financing dominates, international capital also plays an important role, with an average share of about 20% in 2030, which is important for low- and middle-income economies, especially when their domestic financial systems are not well developed, as discussed further later.

Third, in the long run, capital will flow out of economies that experience productivity growth, as reflected in the saving-to-investment ratio being greater than one in most cases in 2050. One reason for the dynamics is that productivity gains gradually diminish over time as developing Asia converges toward the global productivity frontier, reducing the productivity gaps. Also, external financing in early periods must be repaid later, reflecting intertemporal budget constraints.

Fourth, comparing the scenarios, when more economies experience productivity growth, each nation tends to rely more on internal financing, as external financing becomes more expensive due to higher international interest rates driven by productivity growth in more economies.

Lastly, economies exhibit strong heterogeneity in internal and external financing shares, which is partially attributable to differences in trade structure. In particular, trade costs are identified as a key factor in explaining the Feldstein–Horioka puzzle (Obstfeld and Rogoff 2000; Ford and Horioka 2016). In the extreme case of nontradable services, international trade becomes impossible. Even if financial assets could technically move across borders, there would be no goods to exchange for assets, making international capital flows ineffective. This implies that the tradability of goods and services constrains international capital mobility. Thus, cross-economy differences in the degrees of tradability of goods and services contribute to the heterogeneous patterns in the shares of internal and external financing. Since all economies are predominantly based on services, which are mostly nontradable, international capital flows generally account for a relatively small part of private investment in all economies. In addition, international capital mobility is also constrained by financial frictions, which are not modeled here but are addressed later in the discussion.

As international capital flows in, the nominal exchange rate appreciates, and the trade balance deteriorates in the medium term (Table 19). Despite the nominal appreciation, the real exchange rate, which depends on relative productivity changes between tradable and nontradable sectors, tends to depreciate in most cases. In general, high productivity in tradable sectors such as manufacturing tends to increase real exchange rates, while a similar level of productivity in nontradable sectors such as services tends to decrease them. As our scenarios allow the productivity in manufacturing and services to grow together, their impacts on real exchange rates move in opposite directions; however, the overall effect tends to be dominated by the service sector due to its larger size. In fact, even though the nominal exchange rate appreciates, the price level falls due to productivity growth, resulting in depreciation overall.

Productivity growth in one region generates spillover effects in others through international trade and capital flows. There are two opposing forces, one from the capital flow channel and the other from the trade channel. On the one hand, productivity growth in one region would increase real interest rates in others due to financial capital movements, which would negatively impact investment and output in other regions; on the other hand, a region that experiences productivity growth would increase investment and consumption, which would expand imports of intermediate production goods and final consumption goods from other regions. This trade channel generates positive spillover effects on other regions, which partly offsets the negative impacts from the capital flow channel. In the medium run, the capital flow channel dominates as financial capital moves fast, so the overall spillover effect tends to be negative; that is, regions without productivity shocks would experience lower investment and output. But in the long run, the trade channel dominates, and the overall spillover effect tends to be positive, i.e., regions without productivity shocks would benefit from productivity growth in other regions.

Asian economies follow a similar growth strategy focused on developing and exporting manufacturing goods. If multiple regions experience productivity growth together, private investment increases in all those regions, and the real interest rates in those regions also rise by more than the rates would if each region were to be considered alone. Table B4 shows that the real interest rate in each region is higher if more regions experience productivity growth simultaneously. For example, the PRC's interest rate will increase by 0.74 percentage points in 2030 according to its own growth scenario, and by 0.82, 0.95, and 1.13 percentage points, respectively, in the Asia UM, developing Asia, and developing world scenarios. Thus, investment in each region is lower in collective catch-up scenarios than in individual catch-up cases. GDP follows the same pattern across scenarios.

Although developing regions compete for investment in collective catch-up scenarios, it is not a zero-sum game. Compared to individual catch-up scenarios, the reductions in investment and output in collective catch-up scenarios are only modest, although the increases in real interest rates are moderate and, in some cases, strong, suggesting once again that the trade channel dominates the capital flow one, resulting in net positive spillover effects.

Advanced economies are the primary sources of external financing due to their economic size, especially in the collective catch-up scenarios of developing Asia. They would experience slightly lower investment, consumption, and output in the medium term, but modest increases in the long term. As illustrated above, regions without productivity growth are influenced by spillover effects through international trade and capital flows, with the spillover dynamics being shaped by the interplay between the two channels. Also, capital would flow back to advanced economies in the long run, contributing to their own consumption and investment.

5.3 Heterogeneous Impacts from Productivity Growth

There are heterogeneous impacts across regions in response to productivity growth. Different initial productivity levels across regions result in distinct productivity growth rates, so the magnitudes of macroeconomic impacts depend on both relative productivity growth rates across economies and on the relative size of the economies, the economic structure, and the trade structure.

India and Viet Nam experience the strongest productivity growth due to their lowest initial productivity levels, especially in manufacturing sectors, so their output responses are among the strongest in the medium run. The responses of advanced economies differ because they have different trade linkages with developing Asia. In the upper-middle-income scenario, all other advanced economies experience GDP loss in the medium run, with the exception of Australia, which benefits from its close trade relationship with the upper-middle-income group, especially the PRC. However, all advanced economies benefit in the long run.

There are also heterogeneous impacts across sectors within each region, with the heterogeneity coming from several sources. First, the design of our scenarios focuses on agriculture, manufacturing, and services, with manufacturing and services taking the United States as the frontier and this honor going to Japan in agriculture. Second, given the same catch-up rates, different initial productivity levels result in distinct productivity growth rates. In particular, the initial productivity levels in the manufacturing sectors are much lower than those in the service sector. Third, sectors are different by nature, with the durable goods sector being most closely linked to investment, given that investment involves such goods. The heterogeneity across sectors induces structural change within each region. Fourth, the input-output linkages differ across regions.

Table B11 presents sectoral output changes for Asian developing economies in all scenarios. Broadly speaking, the agricultural and manufacturing sectors experience stronger output than others. The service sector sees relatively small increases, given that the productivity gaps between developing regions and the frontier are relatively small. In the medium run, the output of durable manufacturing goods increases the most due to the nature of investment, but in the long run, agricultural output rises by the largest amount. There are strong spillover effects in the energy and mining sectors, although there is no direct productivity growth in either sector.

5.4 Macroeconomic Impacts of Climate Change

Table B12 presents the impacts of climate change on GDP in 2030, 2040, and 2050 expressed as percentage changes relative to the no-climate-damage baseline. Developing regions are generally expected to experience larger GDP losses than advanced economies, with GDP losses in developing Asia ranging from 1.73% to 4.70% in 2050 in SSP2 and from 1.89% to 6.23% in 2050 in SSP5. The PRC, India, Thailand, Malaysia, and Africa, are affected the most, while the Philippines, Viet Nam, and the rest of Asia are less affected. The impacts of climate change would moderately offset those of rapid productivity growth.

Among the four channels of climate shocks, changes in health-related labor productivity, driven by both morbidity and mortality, play the dominant role, with the impacts of heat-related labor productivity changes being relatively small. While temperature increases can significantly affect the agricultural sector, the overall economic impact remains relatively small, given that the agricultural sector accounts for a small fraction in most economies. Additionally, there is strong regional heterogeneity in agriculture across regions. Agricultural productivity may benefit from temperature increases or suffer adverse effects depending on their geographic location. The impacts of sea level-related TFP change are modest.

Table B13 presents annual growth rates of per capita GDP in 2030, 2040, and 2050 in the two climate scenarios. Compared to the baseline, the impacts of climate change on per capita GDP growth by 2050 are modest for some economies and moderate in others, ranging from 0.02% to 0.17% in developing Asia in SSP2, and increasing up to 0.25% in SSP5. Table B14 presents the cumulative growth rates of per capita GDP from 2025 to 2050 (including the growth rate for 2025) and annual average growth rates over the period of 2025–2050. For example, Thailand's average growth rate would decrease by 0.18% and 0.25% every year in SSP2 and SSP5, respectively, resulting in 8.8% and 11.68% less GDP per capita after 25 years in the two scenarios. The PRC is expected to face similar losses, with GDP per capita declining by 8.28% and 10.45% after 25 years in the two scenarios, respectively. India is expected to experience slightly smaller losses, with GDP per capita decreasing by 6.83% and 9.24% in the two scenarios over the same period. Other developing regions in Asia are expected to experience relatively smaller impacts.

6. DISCUSSION

The results above indicate that increased private investment driven by productivity growth can be financed through a combination of domestic saving and international borrowing, with the former playing the dominant role. To put the issue into perspective, some Asian developing economies have high saving rates, attributed to a combination of economic, demographic, and institutional factors, and are net capital exporters. For example, rapid economic growth, population ageing, and underdeveloped social welfare systems create incentives for households to save more; underdeveloped financial systems are not efficient in channeling saving into productive investments. In economies with high saving rates, such as those in East and Southeast Asia, domestic saving can be a critical source of productive investment; however, to fully unlock the potential of domestic resources, institutional and policy reforms are needed to effectively channel domestic saving into productive investment. In contrast, economies with low saving rates, such as those in South Asia, face a dual challenge, as they not only need to incentivize domestic saving but also have to rely more on external resources.

Our model does not incorporate financial intermediaries and thus does not capture the role of financial frictions. In general, financial frictions tend to increase the cost of capital and thus constrain investment. In developing Asia, where financial systems are generally underdeveloped, such frictions are likely to be more pronounced, especially in lower-middle-income economies, and as a result, the increases in the real interest rates generated in the model should be interpreted as their lower bounds, while the rises in investment and output should be seen as their upper bounds. Moreover, financial frictions affect both internal and external financing. Developing economies often face high risk premiums when borrowing from international capital markets, particularly those with weak macroeconomic stability, and such premiums can restrict their access to external financing from private markets, forcing them to rely on concessional loans from multilateral developing banks, which are limited in scale compared to private capital markets. Also, because of financial risks, international capital flows into developing economies primarily in the form of direct investment rather than debt financing.

Externally, Asia's advanced economies, including Japan; the Republic of Korea; Singapore; Taipei,China, and Hong Kong, China, also have abundant savings, and they can serve as key external sources of investment for developing economies in the region. Over the past several decades, they have made substantial direct investments in developing Asian economies. Advanced economies outside Asia, including the United States, Europe, Canada, and Australia, also have vast financial resources and can be important sources of investment in the region. To attract more investment from advanced economies, developing economies must implement further policy and governance reforms. Effective reforms not only improve the productivity of the private sector but also strengthen macroeconomic stability and thus reduce economy risk premiums, which makes external financing more accessible and affordable.

This paper focuses on financing productivity catch-up in Asia under various scenarios; however, it does not explicitly model the specific drivers of productivity growth, given the wide range of drivers and different economic situations across Asian developing economies. Productivity growth can be driven by both domestic and external factors. Domestic drivers include technological innovation, human capital investment, infrastructure investment, market-oriented reforms, and broader policy and governance changes. Meanwhile, on the external front, Asian economies are highly dependent on international trade as part of an export-led growth strategy and on foreign direct investment to build productive capital; thus, their external policies and regulations and, more broadly, geopolitical interactions with advanced economies have strong implications for international trade and investment.

The design of our catch-up scenarios follows a reduced form rather than a structural approach, while the objective of these scenarios is to capture the broad trajectory of economic convergence observed in developing Asia over the past several decades, without attributing the process to specific causal mechanisms. The remarkable historical performance of the region has been driven by a complex interplay of various domestic and external factors, with commonality but also heterogeneity across economies. Instead of focusing on specific structural factors, we take a more holistic approach by extrapolating from historical trends.

The reduced-form approach allows for a more flexible and empirically grounded design of catch- up dynamics. By setting catch-up rates around historical growth patterns, we aim to capture the aggregate outcome of a broad set of underlying drivers, rather than model each specific driver explicitly. The holistic approach provides a practical and convenient way to anchor future scenarios, with the past several decades serving as a benchmark for what is possible, while also ensuring that our projections are not narrowly tied down to particular assumptions on specific drivers in different economies.

Admittedly, future productivity growth depends fundamentally on underlying structural factors, the evolutions of which are subject to considerable uncertainty. Many studies examine specific factors such as trade liberalization and integration, foreign direct investment, population ageing, and innovation across various economy contexts in developing Asia. For example, García-Herrero and Schindowski (2023) show that the PRC has significantly increased R&D expenditure and improved human capital, but several potential bottlenecks, including waning reform momentum, changing preferences in entrepreneurship, and technological decoupling from the United States, constrain the effective translation of innovation into gains in TFP.

We also acknowledge some caveats regarding our estimates of climate impacts. While climate change affects the global economy through various channels, our analysis focuses on selected key ones due to data limitations related to alternative channels at the global level. Also, our analysis focuses only on chronic climate risks from gradual temperature changes and does not account for the impacts of extreme weather events due to data limitations. In addition, climate change can affect the cost of capital, especially in developing economies, which would further suppress investment financing. For example, Buhr et al. (2018) estimate that climate vulnerability increased the average cost of debt by 117 basis points in a sample of developing economies between 1997 and 2016.

7. CONCLUSION

This paper explores alternative productivity growth scenarios among middle-income economies in Asia between 2025 and 2050. This productivity growth is modeled by increasing productivity catch-up rates in key sectors in each developing economy and in the frontier sectors of the world. Our focus is to understand the macroeconomic effects of middle-income economies in Asia achieving higher productivity growth rates—in particular, how national investment would change and how additional investments would be financed by the private sector domestically and globally. We also explore how global financial markets would be affected in terms of changes in global real interest rates, international trade, and capital flows.

Productivity growth in our scenarios increases domestic private investment significantly. This is financed primarily through higher levels of private saving and partially by foreign capital through a deterioration in the trade balance. This shift of investment relative to saving increases real interest rates in the growing economy and those economies experiencing a net capital outflow. The greater the number of economies that experience productivity growth together, the more domestic and foreign interest rates rise as a result of the global and national relocation of financial capital to finance the investment surge. The sectors most impacted are those that experience the highest productivity growth, but the impact also depends on the structure of the economy, including the nature of production networks within and across economies. It is also interesting that the durable goods sectors in the booming economies, as well as those economies that export durable goods to these economies, also benefit because such goods are used to build the additional capital stocks in the booming economies. In the long run, all economies experience higher income from greater productivity growth in Asia; however, the reallocation of global financial capital changes the location of production within economies and across economies.

These results change if economies adjust other policies in response to deteriorating trade balances, especially if these economies use increased tariffs or capital controls to reduce the impact on the trade balance. The less foreign financing of the investment boom, the more economies would need to rely on domestic or government saving, both of which imply higher domestic interest rates and reduced economic benefits from higher productivity catch-up.

The paper considers various productivity catch-up scenarios but does not explore specific drivers of increasing catch-up rates. Productivity growth can be driven by specific domestic or external reforms. Scenarios on domestic reforms may include technological innovation, human capital investment, infrastructure investment, and market-oriented reforms. Scenarios on external linkages might be developed to explore the impacts of geopolitics and the role of external policies and regulations of advanced economies. These types of scenarios are left to future research.

The paper also finds that climate change will negatively impact future economic growth in both developing Asia and globally. Qualitatively, these impacts contrast with those of productivity growth, as climate change is expected to reduce both labor productivity and total factor productivity. Quantitatively, the impacts are moderate in some economies such as the PRC, India, Thailand, and Malaysia, while they remain modest in other economies, including Viet Nam and the Philippines. Our estimates may understate the full impacts of climate change as we do not capture all impact channels, exclude extreme weather events, and overlook the financial impacts of climate change, which will be explored in future research.

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APPENDIX A: SECTORAL PRODUCTIVITY LEVELS IN ALL REGIONS

Tables A1 and A2 present productivity levels by sector and by region in 2017 based on purchasing power parity and market exchange rates, respectively. In general, products in the mining, agriculture, and manufacturing sectors are more tradable, while those in the energy (utilities) and service sectors are less so. For the energy and service sectors, it is appropriate to compare productivity based on purchasing power parity; however, the productivity levels of agriculture in Japan and the Republic of Korea are much lower when measured using purchasing power parity rather than market exchange rates. Similarly, the productivity level of mining in Australia is much lower under purchasing power parity than market exchange rates, while that of manufacturing in the PRC is about half when measured using purchasing power parity. Based on our best judgment, the productivity levels derived from market exchange rates are more reliable for those sectors; thus, we combine the data for the less tradable sectors based on purchasing power parity with the data for the more tradable sectors based on market exchange rates.

Table A1: Productivity Levels by Sector and by Region in Purchasing Power Parity

Regions	Energy	Mining	Agriculture	Manufacturing	Services
USA	100.00	100.00	100.00	100.00	100.00
JPN	48.22	6.26	5.26	68.61	74.72
EUW	25.69	101.57	52.09	52.46	97.21
AUS	31.64	53.86	135.38	43.75	82.38
KOR	84.96	7.57	8.00	44.53	97.12
ADV	85.04	106.05	106.32	40.70	84.27
CHN	54.06	4.72	4.95	7.62	60.29
IDN	47.19	1.96	2.36	6.89	41.49
THA	25.39	4.81	3.23	8.31	78.06
MYS	25.29	2.17	4.15	13.50	22.02
IND	30.54	5.96	0.68	3.32	43.32
PHL	55.94	13.34	4.50	10.65	66.88
VNM	94.84	32.12	14.41	13.58	92.32
ROA	37.86	4.53	2.23	8.57	47.03
LAM	35.33	46.83	17.88	15.75	49.40
AFR	58.82	6.86	3.27	3.53	26.53
MEN	46.28	68.58	7.19	13.72	49.38
ROW	32.77	11.15	7.69	17.30	80.24

Table A2: Productivity Levels by Sector and by Region in Market Exchange Rates

Regions	Energy	Mining	Agriculture	Manufacturing	Services
USA	100.00	100.00	100.00	100.00	100.00
JPN	90.95	14.47	26.44	59.03	63.44
EUW	55.67	89.57	50.17	56.82	66.94
AUS	71.03	123.87	126.19	52.59	89.29
KOR	56.40	21.88	27.21	55.71	43.50
ADV	69.18	87.15	93.48	55.88	68.53
CHN	11.72	10.76	5.45	12.85	16.53
IDN	15.64	5.26	2.52	3.97	5.75
THA	5.55	13.35	4.22	6.88	7.67
MYS	19.67	3.11	3.53	10.07	7.37
IND	11.23	18.89	1.90	2.14	4.33
PHL	17.90	42.00	3.88	11.76	12.90
VNM	16.99	70.03	20.18	16.23	15.99
ROA	10.33	8.99	2.39	8.12	15.17
LAM	23.50	38.95	10.91	18.11	18.92
AFR	7.98	12.59	1.86	3.39	6.80
MEN	7.01	54.07	5.33	10.23	14.85
ROW	9.34	23.32	7.36	13.30	20.11

APPENDIX B: RESULTS

B1: Baseline Growth

Table B1: Growth Rates in GDP and Per Capita GDP at Baseline

	GDP				Per capita GDP					
Region	**2025**	**2030**	**2040**	**2050**	**2025**	**2030**	**2040**	**2050**	**Average**	**Total**
USA	1.90	1.80	1.79	1.60	1.36	1.34	1.43	1.37	1.38	42.94
JPN	0.42	0.59	0.15	0.81	0.95	1.20	0.81	1.46	1.05	31.06
EUW	1.04	0.95	1.14	1.09	1.03	0.96	1.23	1.30	1.14	34.19
AUS	1.99	2.70	2.18	2.05	1.00	1.86	1.48	1.39	1.54	48.62
KOR	1.54	0.95	0.56	0.08	1.64	1.20	1.18	1.09	1.20	36.28
ADV	2.55	2.50	2.19	1.92	1.60	1.83	1.75	1.61	1.74	56.53
CHN	4.20	3.09	1.94	0.62	4.44	3.40	2.44	1.43	2.69	99.25
IDN	3.66	3.26	2.43	1.95	2.85	2.60	2.00	1.78	2.20	76.28
THA	2.62	2.68	1.92	1.57	2.69	2.83	2.26	2.15	2.44	87.38
MYS	3.29	2.89	2.06	1.46	2.08	1.84	1.26	0.95	1.43	44.69
IND	5.52	4.24	2.64	2.09	4.59	3.44	2.14	1.85	2.66	98.06
PHL	5.70	4.26	2.48	2.12	4.85	3.48	1.93	1.90	2.61	95.39
VNM	6.20	3.37	2.34	1.83	5.56	2.88	2.02	1.83	2.50	89.97
ROA	4.08	3.97	2.89	2.45	2.84	2.71	1.86	1.64	2.16	74.21
LAM	3.42	2.72	1.97	1.54	2.73	2.16	1.65	1.46	1.85	61.22
AFR	4.37	4.22	3.23	2.74	1.87	1.89	1.27	1.11	1.47	46.30
MEN	4.15	3.28	2.44	2.18	2.46	1.93	1.32	1.31	1.59	50.65
ROW	0.82	1.94	1.89	1.65	0.59	1.87	1.85	1.67	1.72	55.74

B2: Macroeconomic Variables

Table B2: Changes in Investment (% GDP)

	Own		Asia UM		Asia LM		Developing Asia		Developing World	
Region	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
USA			−0.08	0.14	−0.22	−0.16	−0.30	−0.01	−0.19	0.51
JPN			−0.21	0.22	−0.41	0.09	−0.62	0.30	−0.42	0.88
EUW			−0.20	0.05	−0.27	0.00	−0.47	0.05	−0.39	0.32
AUS			0.92	0.53	−0.19	0.15	0.72	0.68	0.53	0.75
KOR			0.12	0.18	0.02	0.13	0.14	0.32	0.68	1.11
ADV			−0.22	0.12	−0.51	−0.03	−0.73	0.09	−0.89	0.21
CHN	7.55	4.92	7.49	4.94	−0.31	0.02	7.17	4.96	7.08	5.04
IDN	14.74	4.88	14.89	5.09	−0.02	0.12	14.87	5.21	14.45	5.15
THA	11.03	7.88	10.92	7.99	−0.18	0.03	10.73	8.03	10.64	8.15
MYS	6.78	8.92	6.69	9.05	0.07	0.19	6.76	9.24	6.31	8.73
IND	11.69	4.32	−0.23	0.01	11.55	4.30	11.32	4.31	11.52	4.52
PHL	10.92	6.01	0.01	0.07	10.83	6.03	10.84	6.09	10.79	6.24
VNM	11.47	3.85	0.03	0.13	11.37	3.89	11.40	4.02	11.15	3.95
ROA	4.99	3.03	−0.11	0.03	4.92	3.03	4.81	3.06	−0.37	0.09
LAM			−0.23	0.06	−0.37	−0.05	−0.60	0.02	5.95	10.44
AFR			0.09	0.13	−0.05	0.04	0.03	0.18	17.62	14.87
MEN			0.00	0.16	−0.07	0.10	−0.07	0.26	4.31	6.12
ROW			−0.22	0.08	−0.34	−0.02	−0.56	0.06	4.08	6.71

Table B3: Changes in Real GDP (%)

	Own		Asia UM		Asia LM		Developing Asia		Developing World	
Region	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
USA			−0.06	0.07	−0.08	−0.07	−0.14	0.01	−0.09	0.27
JPN			−0.29	0.24	−0.31	0.10	−0.60	0.34	−0.58	0.91
EUW			−0.17	0.04	−0.14	0.00	−0.31	0.04	−0.28	0.30
AUS			0.06	0.22	−0.25	0.04	−0.20	0.27	−0.34	0.35
KOR			−0.03	0.19	−0.01	0.10	−0.04	0.29	0.18	0.81
ADV			−0.17	0.08	−0.21	−0.03	−0.38	0.05	−0.49	0.20
CHN	7.89	11.12	7.85	11.16	−0.18	0.06	7.67	11.22	7.52	11.24
IDN	8.53	7.89	8.46	8.06	−0.11	0.09	8.35	8.15	8.23	8.16
THA	11.48	17.82	11.36	17.95	−0.13	0.05	11.23	17.99	11.16	18.17
MYS	8.05	20.21	7.89	20.42	0.00	0.26	7.89	20.69	7.66	20.06
IND	12.29	12.13	−0.24	0.03	12.18	12.14	11.94	12.17	12.11	12.54
PHL	7.17	11.68	−0.21	0.11	6.99	11.73	6.78	11.85	6.72	12.09
VNM	11.25	10.53	−0.13	0.16	11.13	10.60	11.00	10.76	10.85	10.68
ROA	4.96	7.07	−0.15	0.05	4.90	7.08	4.75	7.13	−0.41	0.13
LAM			−0.28	0.09	−0.25	−0.02	−0.54	0.07	4.77	17.29
AFR			−0.10	0.15	−0.10	0.06	−0.20	0.21	20.40	35.05
MEN			−0.15	0.28	−0.09	0.18	−0.25	0.45	4.01	13.31
ROW			−0.26	0.18	−0.20	0.03	−0.46	0.21	4.29	14.91

Table B4: Changes in Real Interest Rates (Percentage Points)

	Own		Asia UM		Asia LM		Developing Asia		Developing World	
Region	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
USA			0.24	0.04	0.21	0.12	0.45	0.16	0.55	0.16
JPN			0.22	0.06	0.15	0.06	0.37	0.12	0.43	0.23
EUW			0.24	0.05	0.22	0.08	0.46	0.13	0.56	0.24
AUS			0.36	0.08	0.27	0.08	0.63	0.16	0.74	0.28
KOR			0.33	0.07	0.27	0.08	0.60	0.14	0.68	0.26
ADV			0.26	0.06	0.23	0.08	0.49	0.14	0.65	0.25
CHN	0.74	0.06	0.82	0.08	0.24	0.07	1.06	0.15	1.13	0.26
IDN	1.10	0.06	1.39	0.12	0.31	0.09	1.70	0.20	1.79	0.32
THA	0.54	−0.02	0.81	0.04	0.27	0.08	1.08	0.12	1.18	0.24
MYS	0.16	0.01	0.50	0.07	0.27	0.08	0.77	0.15	0.91	0.28
IND	1.97	0.07	0.25	0.05	2.11	0.13	2.37	0.19	2.49	0.32
PHL	1.51	0.11	0.40	0.06	1.81	0.19	2.21	0.25	2.29	0.36
VNM	1.07	−0.05	0.35	0.06	1.37	0.03	1.72	0.09	1.83	0.22
ROA	1.31	0.15	0.18	0.05	1.40	0.16	1.58	0.20	0.39	0.19
LAM			0.28	0.06	0.23	0.08	0.51	0.13	1.43	0.64
AFR			0.25	0.06	0.25	0.08	0.50	0.14	2.54	1.02
MEN			0.23	0.05	0.25	0.06	0.49	0.12	1.16	0.52
ROW			0.28	0.06	0.23	0.07	0.51	0.13	1.07	0.42

Table B5: Changes in Private Consumption (% GDP)

	Own		Asia UM		Asia LM		Developing Asia		Developing World	
Region	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
USA			−0.20	0.22	−0.24	−0.18	−0.44	0.04	−0.44	0.87
JPN			−0.44	0.41	−0.51	0.30	−0.96	0.70	−1.37	0.94
EUW			−0.28	0.14	−0.32	0.09	−0.60	0.23	−0.73	0.51
AUS			−0.32	−0.25	−0.34	−0.04	−0.66	−0.29	−0.96	−0.34
KOR			−0.22	0.15	−0.23	0.03	−0.45	0.18	−0.49	0.47
ADV			−0.24	0.07	−0.28	0.03	−0.52	0.10	−0.75	0.22
CHN	1.44	5.69	1.41	5.73	−0.16	0.11	1.25	5.84	1.13	5.90
IDN	−2.10	2.73	−2.42	2.78	−0.40	0.01	−2.82	2.79	−2.99	2.86
THA	0.41	7.91	0.21	8.03	−0.30	0.06	−0.10	8.09	−0.29	8.24
MYS	2.02	8.99	1.76	9.18	−0.20	0.33	1.56	9.51	1.22	9.05
IND	3.46	7.38	−0.17	0.05	3.36	7.39	3.19	7.44	3.17	7.74
PHL	−1.72	5.10	−0.43	0.08	−2.09	5.11	−2.52	5.18	−2.77	5.25
VNM	−0.06	5.95	−0.31	0.06	−0.32	5.94	−0.63	6.00	−0.75	5.99
ROA	1.21	4.34	−0.20	0.08	1.14	4.38	0.94	4.46	−0.57	0.30
LAM			−0.22	0.07	−0.22	0.02	−0.44	0.09	0.03	6.38
AFR			−0.23	0.10	−0.28	0.06	−0.51	0.16	7.62	19.28
MEN			−0.19	0.26	−0.14	0.25	−0.33	0.51	0.62	6.44
ROW			0.07	0.22	0.04	0.13	0.11	0.36	1.48	7.70

Table B6: Changes in Private Saving (% GDP)

	Own		Asia UM		Asia LM		Developing Asia		Developing World	
Region	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
USA			0.21	−0.07	0.43	0.29	0.64	0.22	0.52	−0.29
JPN			0.48	0.06	0.51	0.34	0.99	0.40	1.59	1.00
EUW			0.32	0.06	0.38	0.16	0.70	0.22	0.91	0.04
AUS			−0.01	−0.25	0.17	0.12	0.16	−0.14	0.41	0.01
KOR			0.07	−0.21	0.14	−0.07	0.21	−0.28	0.35	−0.67
ADV			0.11	−0.13	0.21	0.12	0.32	−0.01	0.53	0.03
CHN	6.20	4.95	6.20	4.93	0.06	0.08	6.26	5.01	6.26	4.89
IDN	9.42	3.64	9.54	3.49	0.24	−0.01	9.78	3.48	10.03	3.79
THA	10.57	10.98	10.55	10.86	0.13	0.05	10.68	10.91	10.78	10.76
MYS	5.74	11.92	5.83	11.86	0.31	0.08	6.13	11.94	6.11	11.48
IND	8.69	4.99	−0.06	0.00	8.69	5.01	8.63	5.00	8.85	5.08
PHL	8.86	6.97	0.01	−0.08	8.92	6.98	8.93	6.91	9.15	7.21
VNM	10.95	5.82	−0.06	−0.03	10.91	5.83	10.85	5.79	10.84	5.85
ROA	3.19	3.10	0.05	0.05	3.20	3.11	3.25	3.15	0.48	0.46
LAM			−0.03	−0.09	0.09	0.08	0.06	−0.02	3.73	8.57
AFR			0.22	−0.01	0.30	0.10	0.52	0.09	11.08	11.65
MEN			0.09	−0.10	0.10	−0.01	0.18	−0.11	2.80	4.33
ROW			0.16	−0.11	0.34	0.14	0.50	0.03	3.50	5.91

Table B7: Changes in Government Deficit (Public Saving) (% GDP)

	Own		Asia UM		Asia LM		Developing Asia		Developing World	
Region	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
USA			0.03	−0.03	0.03	0.02	0.06	−0.01	0.04	−0.13
JPN			0.03	−0.03	0.04	−0.02	0.07	−0.05	0.10	−0.07
EUW			0.06	−0.02	0.06	−0.01	0.11	−0.03	0.11	−0.15
AUS			−0.02	−0.07	0.08	−0.02	0.06	−0.09	0.11	−0.12
KOR			0.01	−0.03	0.01	−0.01	0.02	−0.04	0.02	−0.08
ADV			0.07	−0.02	0.08	0.00	0.16	−0.02	0.20	−0.07
CHN	−0.10	−0.29	−0.10	−0.29	0.01	−0.01	−0.10	−0.30	−0.09	−0.31
IDN	−0.43	−0.55	−0.41	−0.57	0.04	−0.02	−0.38	−0.59	−0.35	−0.59
THA	−0.10	−0.30	−0.12	−0.33	−0.01	−0.02	−0.13	−0.36	−0.14	−0.41
MYS	0.07	0.26	0.08	0.25	0.01	−0.01	0.09	0.23	0.11	0.23
IND	0.33	0.07	0.00	0.00	0.34	0.07	0.33	0.06	0.34	0.06
PHL	0.45	0.23	0.02	0.00	0.47	0.23	0.49	0.23	0.50	0.23
VNM	−0.08	−0.56	0.01	−0.03	−0.07	−0.57	−0.06	−0.60	−0.05	−0.61
ROA	0.15	−0.08	0.02	0.04	0.16	−0.07	0.17	−0.03	0.00	0.10
LAM			0.05	−0.03	0.07	0.00	0.12	−0.03	−0.61	−1.86
AFR			0.00	−0.02	0.01	−0.01	0.01	−0.03	−0.92	−1.29
MEN			0.02	−0.07	0.00	−0.06	0.01	−0.13	−0.52	−1.77
ROW			0.01	−0.04	0.02	−0.02	0.03	−0.05	−0.50	−1.51

Table B8: Private Saving as Share of Investment (%)

	Own		Asia UM		Asia LM		Developing Asia		Developing World	
Region	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
CHN	82.12	100.61	82.78	99.80			87.31	101.01	88.42	97.02
IDN	63.91	74.59	64.07	68.57			65.77	66.79	69.41	73.59
THA	95.83	139.34	96.61	135.92			99.53	135.87	101.32	132.02
MYS	84.66	133.63	87.14	131.05			90.68	129.22	96.83	131.50
IND	74.34	115.51			75.24	116.51	76.24	116.01	76.82	112.39
PHL	81.14	115.97			82.36	115.75	82.38	113.46	84.80	115.54
VNM	95.47	151.17			95.95	149.87	95.18	144.03	97.22	148.10
ROA	63.93	102.31			65.04	102.64	67.57	102.94	NA	NA
LAM									62.69	82.09
AFR									62.88	78.35
MEN									64.97	70.75
ROW									85.78	88.08

Table B9: Changes in Trade Balance (% GDP)

	Own		Asia UM		Asia LM		Developing Asia		Developing World	
Region	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
USA			0.22	−0.29	0.38	0.27	0.60	−0.02	0.54	−1.11
JPN			0.37	−0.39	0.61	−0.28	0.98	−0.67	1.21	−0.92
EUW			0.31	−0.15	0.44	−0.08	0.75	−0.23	0.83	−0.53
AUS			−0.54	−0.06	0.28	−0.06	−0.26	−0.12	0.09	−0.05
KOR			0.06	−0.14	0.21	−0.07	0.27	−0.21	−0.02	−0.76
ADV			0.29	−0.13	0.57	−0.03	0.86	−0.16	1.15	−0.25
CHN	−1.11	0.51	−1.05	0.49	0.29	−0.07	−0.76	0.42	−0.68	0.30
IDN	−4.14	0.22	−4.05	0.12	0.31	−0.04	−3.74	0.08	−3.27	0.08
THA	0.07	2.07	0.27	1.97	0.36	−0.05	0.63	1.93	0.85	1.83
MYS	−0.75	2.30	−0.56	2.19	0.13	−0.26	−0.43	1.93	0.12	2.28
IND	−2.78	0.53	0.16	−0.03	−2.64	0.55	−2.48	0.52	−2.48	0.38
PHL	−2.00	0.60	0.20	−0.03	−1.72	0.63	−1.52	0.60	−1.26	0.63
VNM	−0.14	0.76	0.15	−0.02	0.11	0.80	0.26	0.78	0.46	0.78
ROA	−1.24	−0.30	0.15	−0.06	−1.16	−0.32	−1.01	−0.38	0.53	−0.26
LAM			0.16	−0.04	0.34	0.01	0.50	−0.03	−1.22	0.48
AFR			0.05	−0.08	0.23	−0.05	0.27	−0.13	−4.83	0.90
MEN			0.03	−0.14	0.13	−0.17	0.16	−0.31	−0.91	0.76
ROW			−0.10	−0.12	0.09	−0.09	−0.01	−0.21	−1.27	0.50

Table B10: Changes in Real Exchange Rates (%)

	Own		Asia UM		Asia LM		Developing Asia		Developing World	
Region	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
USA			−0.47	0.94	−0.54	−0.26	−1.01	0.67	0.05	6.48
JPN			0.67	1.23	0.21	1.04	0.88	2.28	1.38	4.80
EUW			−0.19	0.56	−0.06	0.90	−0.24	1.47	0.91	5.41
AUS			1.69	1.16	0.44	0.74	2.14	1.90	2.06	1.84
KOR			0.56	0.49	0.56	0.81	1.12	1.31	2.17	4.14
ADV			−0.01	0.23	−0.17	0.23	−0.18	0.45	−0.16	0.92
CHN	0.02	−2.84	0.15	−2.79	0.53	1.08	0.69	−1.74	1.56	1.44
IDN	−5.95	−7.90	−5.89	−7.51	0.03	1.07	−5.86	−6.52	−6.19	−6.98
THA	−2.74	−4.51	−2.13	−3.68	0.49	0.77	−1.65	−2.94	−1.41	−1.86
MYS	−0.13	−1.42	0.72	−0.62	1.00	1.97	1.73	1.33	1.51	0.40
IND	−2.20	−9.36	−0.09	0.19	−2.14	−9.03	−2.22	−8.86	−1.32	−5.42
PHL	−9.86	−15.69	0.48	0.76	−9.57	−15.01	−9.14	−14.36	−9.44	−14.95
VNM	−9.19	−7.56	0.10	0.55	−9.10	−7.16	−9.01	−6.65	−9.17	−7.05
ROA	0.60	−5.54	−0.19	1.27	0.74	−4.91	0.55	−3.70	−0.88	3.25
LAM			0.07	0.23	−0.14	0.28	−0.06	0.51	−1.68	−11.07
AFR			0.50	0.81	0.20	0.72	0.70	1.54	−5.97	−21.90
MEN			0.52	0.90	0.85	1.13	1.38	2.04	−0.47	−6.21
ROW			0.41	0.40	0.29	0.30	0.70	0.70	−0.19	−5.03

B3: Sectoral Output

Table B11: Changes in Sectoral Output (%)

		Own		Asia UM		Asia LM		Dev. Asia		Dev. World	
Region	**Sector**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
CHN	Energy	4.51	10.59	4.48	10.70	−0.05	0.28	4.43	10.98	4.07	10.16
	Mining	3.98	7.17	4.04	7.29	0.24	0.29	4.28	7.58	4.38	7.65
	Agriculture	8.71	15.52	8.57	15.44	−0.40	−0.19	8.17	15.26	7.79	14.95
	Durable	8.29	8.48	8.43	8.53	0.34	0.28	8.77	8.81	9.14	9.84
	Nondurable	6.95	10.96	6.88	11.03	−0.22	0.03	6.66	11.05	6.43	10.97
	Services	3.37	5.67	3.33	5.70	−0.16	−0.01	3.17	5.69	3.09	5.71
IDN	Energy	5.39	6.43	6.10	7.89	0.83	1.40	6.92	9.29	6.82	7.33
	Mining	6.77	4.86	7.97	6.00	0.88	0.83	8.85	6.82	8.54	6.53
	Agriculture	13.83	22.24	13.52	22.50	−0.83	−0.42	12.69	22.08	12.57	22.35
	Durable	32.96	12.88	33.55	13.46	0.90	0.88	34.45	14.35	34.55	14.97
	Nondurable	15.19	13.87	14.91	14.11	−0.37	0.21	14.54	14.31	14.53	14.77
	Services	2.71	1.61	2.56	1.59	−0.20	−0.07	2.37	1.52	2.34	1.66
THA	Energy	2.38	5.59	2.23	5.88	0.57	0.66	2.80	6.54	1.95	4.30
	Mining	4.91	7.02	6.12	8.68	3.79	3.47	9.91	12.15	8.52	11.39
	Agriculture	12.86	34.44	13.29	35.75	−1.50	−3.01	11.79	32.74	11.11	31.16
	Durable	14.97	14.24	16.40	14.60	1.50	1.16	17.90	15.75	19.06	17.82
	Nondurable	9.03	13.81	8.66	13.96	−0.46	−0.04	8.20	13.92	8.03	14.05
	Services	8.22	14.64	7.76	14.66	−0.38	0.02	7.38	14.67	7.26	14.90
MYS	Energy	0.11	5.43	0.48	8.09	1.14	2.82	1.61	10.91	0.08	0.44
	Mining	10.44	28.95	12.05	30.28	4.40	4.76	16.44	35.04	14.50	37.41
	Agriculture	3.94	12.16	3.33	11.35	−1.49	−2.97	1.85	8.38	1.56	7.80
	Durable	15.30	37.11	17.03	37.24	1.81	1.53	18.85	38.77	20.18	42.45
	Nondurable	7.57	21.38	7.04	21.50	−0.57	−0.09	6.48	21.42	6.46	21.50
	Services	3.12	7.97	2.67	8.04	−0.36	−0.13	2.30	7.91	2.13	7.65
IND	Energy	2.68	6.58	−0.01	0.23	2.93	6.91	2.92	7.14	2.54	6.10
	Mining	7.39	8.69	1.24	1.14	7.88	9.25	9.12	10.39	9.24	10.21
	Agriculture	14.62	18.99	−0.26	−0.07	14.44	18.86	14.18	18.80	14.28	19.26
	Durable	26.06	11.97	−0.36	−0.21	26.08	12.10	25.71	11.89	26.85	13.17
	Nondurable	15.53	17.86	−0.34	−0.01	15.38	17.90	15.04	17.90	15.26	18.62
	Services	7.02	8.49	−0.18	0.09	6.91	8.49	6.73	8.58	6.83	9.00
PHL	Energy	8.38	14.86	−0.72	0.36	7.89	15.04	7.17	15.41	6.84	15.85
	Mining	10.36	11.64	0.89	0.83	11.09	12.33	11.98	13.16	12.18	13.14
	Agriculture	7.14	16.85	−0.40	0.03	6.64	16.55	6.24	16.58	6.12	16.79
	Durable	21.38	17.14	1.10	0.58	22.28	18.02	23.38	18.61	24.04	19.74
	Nondurable	6.49	12.44	−0.44	0.12	6.12	12.47	5.68	12.59	5.60	12.95
	Services	6.31	10.56	−0.29	0.10	6.08	10.57	5.78	10.66	5.76	10.91
VNM	Energy	6.77	6.13	0.40	1.35	6.87	6.88	7.27	8.24	6.94	6.40
	Mining	4.92	2.82	1.41	1.55	6.82	4.52	8.23	6.06	8.04	5.96
	Agriculture	13.24	20.61	−0.04	0.16	12.83	19.96	12.78	20.12	12.59	19.63
	Durable	17.69	6.44	*0.39*	0.14	18.30	7.06	18.70	7.21	18.75	7.70
	Nondurable	9.10	7.93	−0.22	0.13	8.87	8.05	8.65	8.18	8.74	8.45
	Services	11.47	8.31	−0.21	0.13	11.30	8.43	11.10	8.56	10.90	8.63
ROA	Energy	10.87	12.61	0.03	0.46	10.90	12.73	10.92	13.20	−0.40	0.31
	Mining	11.33	12.38	0.06	0.21	11.39	12.50	11.45	12.71	−0.02	0.54
	Agriculture	7.69	15.77	−0.27	0.06	7.56	15.74	7.29	15.80	−0.76	0.14
	Durable	14.12	9.79	0.10	0.19	14.20	9.89	14.30	10.08	0.12	0.80
	Nondurable	5.44	8.94	−0.20	0.08	5.35	8.98	5.15	9.05	−0.53	0.31
	Services	3.10	4.54	−0.13	0.04	3.04	4.55	2.92	4.58	−0.32	0.11

B4: Climate Impacts

Table B12: GDP Impacts of Climate Change (%)

	SSP2			SSP5		
Region	**2030**	**2040**	**2050**	**2030**	**2040**	**2050**
USA	−0.61	−0.86	−1.17	−0.65	−0.96	−1.38
JPN	−0.81	−1.68	−2.50	−0.97	−2.17	−3.61
EUW	−0.08	−0.30	−0.42	−0.07	−0.34	−0.51
AUS	−0.64	−1.09	−1.31	−0.72	−1.30	−1.65
KOR	−0.46	−0.82	−1.28	−0.61	−1.21	−1.91
ADV	0.70	0.39	0.39	0.87	0.49	0.53
CHN	−1.82	−2.88	−4.15	−2.11	−3.45	−5.25
IDN	−2.18	−2.49	−3.08	−2.54	−3.25	−4.22
THA	−2.80	−3.46	−4.70	−3.32	−4.80	−6.23
MYS	−2.37	−2.94	−4.03	−2.77	−3.97	−5.75
IND	−2.07	−2.65	−3.45	−2.39	−3.49	−4.66
PHL	−1.05	−1.51	−1.73	−1.16	−1.89	−2.48
VNM	−1.17	−1.55	−1.90	−1.35	−2.06	−2.55
ROA	−1.44	−1.76	−2.15	−1.71	−2.27	−2.95
LAM	−1.36	−1.95	−2.57	−1.59	−2.47	−3.48
AFR	−3.91	−4.32	−5.10	−4.31	−5.13	−6.42
MEN	−1.57	−2.42	−2.85	−1.79	−2.81	−3.71
ROW	−0.14	−0.78	−1.03	−0.16	−0.89	−1.35

Table B13: Annual Growth of Per Capita GDP (%)

	Baseline			SSP2			SSP5		
Region	**2030**	**2040**	**2050**	**2030**	**2040**	**2050**	**2030**	**2040**	**2050**
USA	1.34	1.43	1.37	1.31	1.40	1.33	1.29	1.39	1.32
JPN	1.20	0.81	1.46	1.07	0.77	1.39	1.04	0.70	1.27
EUW	0.96	1.23	1.30	0.91	1.22	1.29	0.89	1.22	1.28
AUS	1.86	1.48	1.39	1.78	1.46	1.37	1.76	1.44	1.35
KOR	1.20	1.18	1.09	1.15	1.17	1.03	1.14	1.11	0.98
ADV	1.83	1.75	1.61	1.79	1.74	1.60	1.79	1.76	1.60
CHN	3.40	2.44	1.43	3.24	2.35	1.26	3.21	2.31	1.18
IDN	2.60	2.00	1.78	2.45	2.01	1.73	2.44	1.87	1.73
THA	2.83	2.26	2.15	2.71	2.21	2.01	2.69	1.95	1.99
MYS	1.84	1.26	0.95	1.77	1.22	0.85	1.77	1.07	0.82
IND	3.44	2.14	1.85	3.23	2.12	1.77	3.17	2.04	1.70
PHL	3.48	1.93	1.90	3.35	1.94	1.88	3.32	1.90	1.85
VNM	2.88	2.02	1.83	2.77	2.02	1.79	2.75	1.93	1.78
ROA	2.71	1.86	1.64	2.61	1.86	1.61	2.57	1.80	1.59
LAM	2.16	1.65	1.46	2.05	1.61	1.41	2.02	1.56	1.35
AFR	1.89	1.27	1.11	1.78	1.26	1.08	1.74	1.14	1.04
MEN	1.93	1.32	1.31	1.75	1.29	1.25	1.72	1.25	1.22
ROW	1.87	1.85	1.67	1.81	1.81	1.63	1.80	1.80	1.62

Table B14: Average and Total Growth of Per Capita GDP Over 2025–2050 (%)

	Baseline		SSP2		SSP5	
Region	**Average**	**Total**	**Average**	**Total**	**Average**	**Total**
USA	1.38	42.94	1.34	41.27	1.33	40.97
JPN	1.05	31.06	0.95	27.79	0.90	26.33
EUW	1.14	34.19	1.12	33.62	1.12	33.50
AUS	1.54	48.62	1.48	46.66	1.47	46.16
KOR	1.20	36.28	1.15	34.54	1.12	33.67
ADV	1.74	56.53	1.75	57.15	1.76	57.36
CHN	2.69	99.25	2.52	90.97	2.47	88.80
IDN	2.20	76.28	2.08	70.86	2.03	68.84
THA	2.44	87.38	2.26	78.58	2.19	75.70
MYS	1.43	44.69	1.27	38.86	1.20	36.38
IND	2.66	98.06	2.52	91.23	2.47	88.82
PHL	2.61	95.39	2.54	92.00	2.51	90.55
VNM	2.50	89.97	2.42	86.36	2.40	85.13
ROA	2.16	74.21	2.07	70.45	2.04	69.07
LAM	1.85	61.22	1.75	57.08	1.72	55.60
AFR	1.47	46.30	1.27	38.84	1.22	36.92
MEN	1.59	50.65	1.48	46.35	1.44	45.06
ROW	1.72	55.74	1.68	54.14	1.67	53.64