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Drivers of Economic Catch-up in Asia: A Study of ASEAN Countries with Comparative Views of China and India

Khuong Vu[3] and Hieu Nguyen[4]

Abstract

This paper conducts a comprehensive examination of the sources of economic growth and catch-up of ASEAN countries since the Asian financial crisis, with comparative views of China and India. The study employs different decomposition frameworks to gain insights into the drivers of ASEAN economic performance over 1997-2017. Three findings are most notable. First, ASEAN countries, except for Brunei, recorded a strong catch-up performance, with labour productivity being the leading driver in most countries. Second, the drivers of labour productivity catch-up exhibit some distinctive patterns among countries, which depend on the level of income and economic structure. Third, in all decomposition analyses, ASEAN countries are well below China and India across sources of growth, which tends to suggest that ASEAN countries could improve their performance by enhancing market integration and policy coordination. Although the long-term prospect of ASEAN is bright, the COVID-19 pandemic and the recent military coup in Myanmar have indicated that the road to future prosperity of the region is expected to unexpectedly face formidable challenges.

Key words: economic growth; catch-up; structural change; productivity; Asia.
JEL codes: O40; O48; O57.

1. Introduction

The phenomenal success of East Asian economies in terms of economic growth in the second half of the 20th century has brought to the fore an economic development model, which was

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coined the "East Asian Miracle" by the World Bank (1993)[5]. While the model has been widely praised by academics and development experts, it does not go without blunt criticism. On the one hand, many studies, including Page (1994) and Stiglitz (2001), offer inspiring lessons from the East Asian Miracle (EAM) model, which range from getting the fundamentals right to fostering capital accumulation and human capital development to promoting exports and structural change. On the other hand, Krugman (1994), with reference to the work by Young (1992, 1994) and Kim and Lau (1994), contended that the East Asian miracle was largely attributed to "perspiration" (mobilization of input factors) rather than "inspiration" (improvement of total factor productivity). Based on this analysis, Krugman pessimistically predicted that "from the perspective of the year of 2010, current projections of Asian supremacy extrapolated from recent trends may well look almost as silly as 1960s-vintage forecasts of Soviet industrial supremacy did from the perspective of the Brezhnev years[6]" (Krugman 1994, p. 77).

Although the EAM model is no longer a hot debate today, it is still important to better understand this growth model. With this motivation, this paper conducts an in-depth analysis of the economic performance of 10 ASEAN economies: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam, over the period from 1997 to 2017.

The study aims to address the following three research questions. First, how did ASEAN countries perform in the global dynamics of economic catch-up during 1997-2017? Second, what are the drivers and draggers of ASEAN economies' economic growth and catch-up during this 20-year period? Finally, what are the policy insights that are important for developing countries in their efforts to promote economic growth and catch-up?

In addressing the three research questions above, this study also provides insights into the validity and robustness of the EAM model. As the Asian financial crisis (AFC), which erupted in

[5] This model is drawn from the growth experience of eight economies during 1960-1990, including four in Northeast Asia (Japan, Hong Kong, the Republic of Korea, and Taiwan) and four in Southeast Asia (Indonesia, Malaysia, Singapore, and Thailand).

[6] The Brezhnev years are the early 1980s when the Soviet Union's economy under the leadership of Brezhnev was stagnant due to serious problems of inefficiency and diminishing returns to scale.

1997, severely affected Asian economies several years later, the results from this study provide evidence of whether the EAM model remains valid for the post-crisis period. At the same time, the vast diversity of the 10 ASEAN economies in various dimensions, including the level of economic development, religious belief, population size, and political settings, would imply whether the EAM model is robust to country characteristics.

The remainder of this paper is organized as follows. Section 2 provides a snapshot of the 10 ASEAN countries. Section 3 presents the catch-up performance and its primary drivers for each individual ASEAN economy. Section 4 analyses the sources of labour productivity growth and catch-up performance using the growth accounting and industry origin approaches, respectively. Section 5 summarizes the results and concludes with a brief discussion of policy implications. There are three appendices at the end of the paper. Appendix 1 describes the frameworks for decomposing the sources of per capita income and labour productivity growth, while Appendix 2 introduces the frameworks for quantifying the sources of per capita income and labour productivity catch-up performance. Appendix 3 elaborates the data sets used for this study.

2. ASEAN economy in a snapshot

The ASEAN economy stands out with three distinctive features. First, the region, which is home to more than 650 million people, or 8.6 per cent of the world's population (Table 1), is a large and vibrant economy. In terms of GDP, the ASEAN economy is larger than Japan in PPP$ (8,565 billion vs. 5,485 billion) and India in US$ (2,969 billion vs. 2,726.3 billion). The 10 ASEAN countries, however, vary largely on the level of economic development, ranging from Myanmar and Cambodia, which are among the world's poorest countries, to Singapore and Brunei, which have high levels of per capita income comparable to that of the US. In addition, during 1997-2017, the ASEAN economy as a whole grows faster than the world average (5.1 per cent vs. 3.6 per cent), with its lower-income countries (Cambodia, Laos, Myanmar, the Philippines, and Vietnam) exhibiting stronger performance (Table 1).

Table 1: ASEAN countries: selected socio-economic indicators, 2018

Economy	Population (Million)	Total GDP, current price (Billion)		GDP per capita, current price				*GDP growth (2015-18)*
		PPP$	US$	PPP$	US$	World Average=100		
						PPP$	US$	
Brunei	0.4	34.7	13.6	80,778	31,628	449.5	280.0	*-0.4%*
Cambodia	16.2	70.8	24.6	4,354	1,512	24.2	13.4	*7.2%*
Indonesia	267.7	3,494.8	1,042.2	13,057	3,894	72.7	34.5	*5.1%*
Lao PDR	7.1	52.5	18.1	7,441	2,568	41.4	22.7	*6.8%*
Malaysia	31.5	999.4	354.3	31,698	11,239	176.4	99.5	*4.9%*
Myanmar	53.7	357.8	71.2	6,662	1,326	37.1	11.7	*6.3%*
Philippines	106.7	953.0	330.9	8,935	3,103	49.7	27.5	*6.6%*
Singapore	5.6	571.5	364.2	101,353	64,582	564.0	571.7	*3.3%*
Thailand	69.4	1,320.4	505.0	19,018	7,274	105.8	64.4	*3.8%*
Vietnam	95.5	710.3	244.9	7,435	2,564	41.4	22.7	*6.7%*
ASEAN	**653.9**	**8,565.1**	**2,969.0**	**13,098**	**4,540**	**72.9**	**40.2**	***5.1%***
China	1,392.7	25,361.7	13,608.2	18,210	9,771	101.3	86.5	*6.7%*
India	1,352.6	10,498.5	2,726.3	7,762	2,016	43.2	17.8	*7.4%*
Japan	126.5	5,485.0	4,970.9	43,349	39,287	241.2	347.8	*1.1%*
The US	327.2	20,494.1	20,494.1	62,641	62,641	348.6	554.5	*2.2%*
World	**7,594.3**	**136,460.5**	**85,790.8**	**17,969**	**11,297**	**100.0**	**100.0**	***3.6%***

Sources: Authors, data from World Bank (2019).

Second, ASEAN countries have made significant reform efforts to embrace global megatrends, such as globalization and the information and communication technology (ICT) revolution, to promote economic growth. In fact, ASEAN countries rank impressively in terms of the key measures on openness and ICT penetration indicators[7] (Table 2). Furthermore, it is interesting to note that the least developed ASEAN countries are exhibiting inspiring examples of turning mishaps and disadvantages to commitment and advantages in building prosperity as in the case of Laos (Bird and Hill 2010).

[7] It should be noted, however, that Indonesia is far behind other ASEAN countries on the openness measures: 43 per cent in trade-to-GDP; 22 per cent in FDI stock-to-GDP, and 6 per cent in FDI inflows-to-gross fixed capital formation (GFCF). Patunru and Rahardja (2015) attributes this problem of Indonesia to its increased protectionism amidst intensified regional competition for FDI.

Besides, with their strategic location between two rising economic giants, China and India, ASEAN countries possess a strategic advantage that positions them to reap the most from the rise of Asia in the coming decades.

Table 2: ASEAN countries: Openness and ICT penetration, 2018

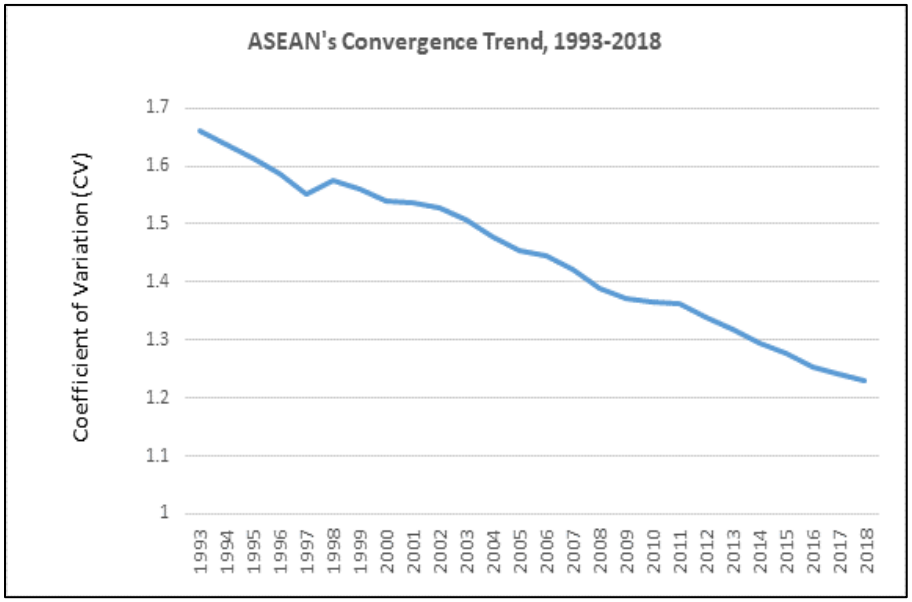
Economy	Openness (%)			ICT Penetration (per 100 population)			
	Trade to GDP	FDI stock to GDP	FDI inflows to GFCF	Mobile phone subscribers	Internet users	Fixed broadband subscribers	Facebook users
Brunei	94	48	11	132	95	11.5	79.5
Cambodia	125	97	57	119	32	1.0	38.9
Indonesia	43	22	6	119	32	3.3	48.6
Lao PDR	75.8*	48	33	52	26	0.6	31.0
Malaysia	131	43	12	135	80	8.6	69.8
Myanmar	51	45	21	114	31	0.2	29.8
Philippines	76	25	11	126	60	3.7	58.1
Singapore	326	426	105	149	84	28.0	76.8
Thailand	123	44	6	180	53	13.2	66.3
Vietnam	208	59	27	147	58	13.6	52.4
ASEAN	**120**	**81**	**19**	**131**	**45.4**	**6.1**	**51.9**
China	*38*	*12*	*3*	*116*	*54*	28.5	*0.01*
India	*43*	*14*	*5*	*87*	*34*	1.3	*22.2*
United States	*28*	*36*	*7*	*129*	*87*	33.8	*73.3*
World	**59**	**38**	**7**	**106**	**50**	14.5	**28.3**

*Note: *Data for 2017.*
Sources: Authors, data from World Bank (2019) and World Internet Statistics.

Third, ASEAN countries have made impressive progress on narrowing down their income gap in recent decades. In fact, as shown in Figure 1, the covariation of coefficient (CV)[8] of per capita income consistently declined since 1993, with the exception of 1998 when the region was in turmoil caused by the Asian Financial Crisis that struck the year before.

[8] The coefficient of variation is also known as the sigma convergence coefficient. The CV of a set of observations on a given measure is calculated as its standard deviation divided by its mean. This is a common measure used to assess the converge trends of groups of countries, such as those in the EU (for example, see Boyle and McCarthy (1997)).

Figure 1: ASEAN's convergence trend on per capita income



Source: Author, data from World Bank (2019).

3. Economic catch-up performance and its primary drivers

This section examines the performance of ASEAN nations in the global dynamics of economic catch-up over the period 1997-2017. The section then quantifies two primary drivers of the catch-up performance for each economy: labour productivity growth and employment-to-population rate.

3.1. Economic catch-up performance

Using the US income level as the benchmark, one can assess the catch-up performance of a given country during a period by examining how much the country's income has changed over this period relative to the US income. One simple measure to capture these dynamics is the catch-up performance index (CUPI) described below (Vu 2020)[9]:

$$CUPI_{0,T}^{i} = ln\left[\frac{rel\_y_{T}^{i}}{rel\_y_{0}^{i}}\right]/T * 100 \qquad (1)$$

[9] This index extends the "Catch-up Index" (CUI) introduced by Woo (2011). While CUI is simply the relative per capita income of a country in comparison to the US for a given year, the CUPI captures the change in the CUI over a period of interest.

where $CUPI_{0,T}^{i}$ is the CUPI of country i over period [0, T]; $rel\_y_t^i$ is relative per capita income measured in purchasing power parity (PPP) dollars at constant prices of country i in year t, in comparison to the US ($rel\_y_t^i = y_t^i / y_t^{US}$).

By definition, if country i is catching up or forging ahead, its relative income improves, $rel\_y_T^i > rel\_y_0^i$, which means $CUPI_{0,T}^{i}$>0. Conversely, if country i is falling behind, its relative income gap with the US deteriorates, $rel\_y_T^i < rel\_y_0^i$, which means $CUPI_{0,T}^{i}$<0.

That is, the sign and magnitude of the CUPI index provide a meaningful measure to assess the catch-up performance of a given country in terms of per capita income over the period under investigation. It is worth noting that CUPI can be roughly interpreted as the per capita growth difference between the country in question and the US.

The catch-up performance captured by CUPI for 10 ASEAN countries are reported in Table 3. For comparison, the results for China and India are also reported. The following findings stand out from Table 3.

First, all ASEAN countries, with the exception of Brunei, recorded a strong economic catch-up performance over 1997-2017, with their CUPI ranging from 1.2 for Malaysia to 7.2 for Myanmar. Brunei is the worst performer not only among ASEAN countries but also worldwide, falling into the 170th place in the global ranking by CUPI.[10]

Second, the four least developed ASEAN countries – Myanmar, Cambodia, Laos, and Vietnam – are among the world's top 20 performers in the global ranking by CUPI. In addition, the convergence among ASEAN countries in terms of relative per capita income (US=100) over 1997-2017 is solid. In fact, the CV of their relative income declined from 1.6 to 1.2, driven by both a significant fall in the standard deviation and a rise in the mean of relative income. This finding indicates that the convergence effect (Barro 1998) tends to be more robust among ASEAN countries over the past decades.

[10] Two reasons may explain Brunei's fall in relative income, which results in its negative CUPI. One is its high income level compared with that of the US (198.8 per cent in 1997 and 132.4 per cent in 2017). Another is the less favourable conditions of the oil industry, which dominates Brunei's economy.

Third, most ASEAN countries, with the exception of Myanmar and Cambodia, were well behind China and India on the CUPI measure. That is, ASEAN as a whole significantly underperformed these two Asian economic giants in the global dynamics of economic catch-up over 1997-2017. The economic integration and economy of scale could be a significant factor explaining the stronger economic performance of China and India in comparison to ASEAN economy as a whole. From this perspective, it is plausible to believe that ASEAN countries could collectively improve their economic catch-up performance if they made more strategic efforts to enhance the region's market integration and policy coordination.

Table 3: ASEAN's catch-up performance, 1997-2017

(ASEAN countries are sorted in decreasing order by CUPI)

Economy	**Catch-up performance (1997-2017)**		**Relative income per capita (US=100)***	
	CUPI	**Global rank**	**1997**	**2017**
Myanmar	**7.23**	1	2.4	10.3
Cambodia	**4.51**	8	2.7	6.7
Lao PDR	**3.99**	10	5.3	11.8
Vietnam	**3.76**	16	5.4	11.4
Philippines	**1.65**	50	10.1	14.0
Singapore	**1.53**	52	116.2	157.7
Thailand	**1.43**	58	22.5	30.0
Indonesia	**1.35**	65	15.8	20.6
Malaysia	**1.16**	74	39.2	49.4
Brunei	**-2.03**	170	198.8	132.4
China	**6.82**	2	7.2	28.2
India	**4.07**	9	5.2	11.9
ASEAN Convergence Trend				
Mean (M)			***41.8***	***44.4***
Std. Deviation (SD)			***65.0***	***54.8***
Coefficient of Variation (CV=SD/M)			***1.6***	***1.2***

*Note: *using per capita GDP measured in current PPP$.*
Source: Authors, calculated from data of World Bank (2019).

3.2. Primary sources of per capita income growth and economic catch-up performance

This section examines the primary sources of income growth (INCG) and of the economic catch-up performance captured by CUPI.

As specified in Eq (A1) in Appendix 1, INCG can be decomposed into two primary drivers, labour productivity growth (LPG) and employment-to-population change (E2PC). At the same time, Eq (A5) in Appendix 2 decomposes the catch-up performance index, CUPI, into two primary drivers: the differences between the country in question and the US on LPG (Diff-in-LPG) and on E2PC (Diff-in-E2PC). The decomposition results, which are reported in Table 4, reveal the findings below.

First, LPG plays a dominant role in driving INCG across countries. For ASEAN, the share of LPG in INCG ranges from 70.3 per cent for Malaysia to 105 per cent for Thailand. These results support the observation by Felipe (1999) that labour productivity growth is a prevailing trend in East Asian economies. It should be noted, however, that Brunei, for which INCG is negative, LPG accounted for 141 per cent of Brunei's decline in per capital income.

Second, E2PC makes a positive contribution to LPG for all ASEAN countries, with the exception of Thailand. This contribution ranges from 0.30 percentage points (ppts) for Brunei to 1.42 ppts for Cambodia. Thailand is the only ASEAN country that experienced negative E2PC (-0.13 ppts), which is likely due to a combination of two reasons: population aging and stagnation in job creation. It should be noted that E2PC for Singapore is positive and sizable (+0.73) although the country faces the most serious problem of population ageing among the ASEAN nations. This can be explained by Singapore's robust efforts in attracting foreign workers and fostering job creation. For comparison, negative E2PC is observed for China (-0.07 ppts) and India (-0.28 ppts). However, the key reasons behind this E2P ratio deterioration in China and India are different. For China, it is driven by population aging, while for India, it is due to employment expansion falling behind the country's rapid population growth.

Third, with the exception of Brunei, both Diff-in-LPG and Diff-in-E2PC are positive in contributing to the CUPI for all ASEAN countries. That is, both labour productivity growth and labour participation growth were drivers of these ASEAN countries' catch-up performance over 1997-2017.

It is worth noting that Diff-in-E2PC has a large contribution to the CUPI for Malaysia (76.3 per cent) and Singapore (57.8 per cent). For Brunei, the role of Diff-in-E2PC is even more important, as it is the only factor preventing the country's income from falling. This observation tends to suggest that higher-income ASEAN countries have been prone to import more immigrant labourers to sustain per capita income growth.

For comparison, Diff-in-LPG is the dominant source of the CUPI for China (98.7 per cent) and India (103 per cent), which is larger than the share observed for ASEAN countries, which ranges from 23.7 per cent for Malaysia to 58.6 per cent for Indonesia to 69.9 per cent for Vietnam and 98.4 per cent for Thailand. This finding suggest that ASEAN countries should focus more on boosting LPG to enhance their catch-up performance.

Table 4. Primary sources of ASEAN countries' per capita income growth and catch-up, 1997-2017

Country	INCG and primary sources					CUPI and primary sources				
	Percentage			INCG=100		CUPI	ppts		CUPI=100	
	INCG	LPG	E2PC	LPG	E2PC		Diff-in-LPG	Diff-in-E2PC	Diff-in-LPG	Diff-in-E2PC
Myanmar	8.53	7.81	0.72	91.6	8.4	**7.23**	6.35	0.88	87.9	12.1
Cambodia	5.81	4.39	1.42	75.6	24.4	**4.51**	2.93	1.58	65	35
Laos	5.29	4.63	0.67	87.5	12.7	**3.99**	3.17	0.82	79.4	20.6
Vietnam	5.06	4.08	0.97	80.6	19.2	**3.76**	2.63	1.13	69.9	30.1
Philippines	2.95	2.63	0.32	89.2	10.8	**1.65**	1.18	0.47	71.3	28.7
Singapore	2.83	2.1	0.73	74.2	25.8	**1.53**	0.65	0.88	42.2	57.8
Thailand	2.73	2.87	-0.13	105.1	-4.8	**1.43**	1.41	0.02	98.4	1.6
Indonesia	2.65	2.24	0.4	84.5	15.1	**1.35**	0.79	0.56	58.6	41.4
Malaysia	2.46	1.73	0.73	70.3	29.7	**1.16**	0.28	0.89	23.7	76.3
Brunei	-0.73	-1.03	0.3	141.1	-41.1	**-2.03**	-2.49	0.45	122.3	-22.3
China & India										
China	8.12	8.19	-0.07	100.9	-0.9	**6.82**	6.73	0.09	98.7	1.3
India	5.37	5.65	-0.28	105.2	-5.2	**4.07**	4.19	-0.12	103	-3
Memorandums										
The U.S.	1.3	1.46	-0.16	112.3	-12.3	**0**	0	0	---	---

Note: ASEAN countries are sorted in decreasing order by INCG.
Source: Authors, calculated from data of World Bank (2019).

4. Sources of labour productivity growth and catch-up

This section examines the sources of labour productivity growth (LPG) and catch-up (Diff-in-LPG) during the 1997-2017 period. As presented in Section 3, LPG is the main driver of INCG while Diff-in-LPG is the main contributor to the per capita income catch-up performance of all ASEAN nation, with the exception of Brunei.

The examination quantifies the sources of LPG and Diff-in-LPG using two decomposition approaches, growth accounting and industry origin, for which the decomposition frameworks are presented in Appendices 1 and 2.

4.1. Results from growth accounting decompositions

The decomposition results based on the growth accounting method as specified in Appendices 1 and 2 (Eq (A2) for LPG and Eq (A6) for Diff-in-LPG) are reported in Table 5. The following findings are drawn from Table 5.

First, for most ASEAN countries, both capital deepening (kCon) and TFP growth play a significant role in driving LPG. In fact, kCon is positive for all ASEAN countries, ranging from 0.88 ppts for Singapore to 5.03 ppts for Myanmar, while TFPG is positive for most countries, with the exception of Indonesia. For comparison, this pattern is more solid for China (kCon: 4.75 ppts; TFPG: 3.44 ppts) and India (2.72 ppts and 2.93 ppts). For the case of Indonesia, Aswicahyono, Hill and Narjoko (2010) points out the factor explaining Indonesia's weak TFPG after the Asian financial crisis, which include policy uncertainty and diminished dynamism of businesses due to the consequences of the crisis.

Second, capital deepening is a robust driver of ASEAN's catch-up performance, while TFP growth is a positive contributor for only six of the countries. In fact, Diff-in-kCon is positive for all countries and ranges from 0.36 ppts for Singapore to 4.51 ppts for Myanmar. Furthermore, Diff-in-kCon is a leading driver of Diff-in-LPG for ASEAN countries (with the exception of Thailand), with its share ranging from 56 per cent for Singapore to 221 per cent for Indonesia. This pattern is also observed for China (62.9 per cent) and India (52.4 per cent).

Third, Diff-in-TFPG is negative for four countries: Brunei (-3.12 ppts), Indonesia (-0.95 ppts), Vietnam (-0.40 ppts), and Malaysia (-0.25 ppts). It is worth noting that despite impressive performance in terms of enhancing labour productivity, Vietnam seems to have been biased towards capital accumulation while undergoing rather weak TFP improvement. For comparison, the sources of catch-up performance are more robust for China (Diff-in-kCon: 4.23 ppts; Diff-in-TFPG: 2.5 ppts) and India (2.2 ppts; 2.0 ppts).

The above findings generally support the conclusions of studies on growth drivers of East Asian countries after the AFC. These studies revealed that though East Asian economies continued to be primarily driven by factor accumulation, the productivity gains have begun to play a larger role since early 2000s (Park and Park 2010; Lee and Hong 2010).

Table 5. Sources of ASEAN countries' labour productivity growth and catch-up, 1997-2017: Growth accounting decomposition

Country	LPG and sources					Diff-in-LPG and sources				
	ppts			LPG=100		ppts			Diff-in-LPG=100	
	LPG	kCon	TFPG	kCon	TFPG	Diff-in-LPG	Diff-in-kCon	Diff-in-TFPG	Diff-in-kCon	Diff-in-TFPG
Myanmar	7.81	5.03	2.77	64.4	35.5	6.35	4.51	1.84	71.1	28.9
Laos	4.63	2.36	2.27	51.0	49.0	3.17	1.84	1.33	57.9	42.1
Cambodia	4.39	2.27	2.11	51.7	48.1	2.93	1.76	1.18	59.9	40.1
Vietnam	4.08	3.55	0.53	87.0	13.0	2.63	3.03	-0.4	115.3	-15.3
Thailand	2.87	1.11	1.76	38.7	61.3	1.41	0.59	0.82	41.6	58.4
Philippines	2.63	1.3	1.33	49.4	50.6	1.18	0.78	0.4	66.4	33.6
Indonesia	2.24	2.26	-0.02	100.9	-0.9	0.79	1.74	-0.95	221.1	-121.1
Singapore	2.1	0.88	1.22	41.9	58.1	0.65	0.36	0.28	56.0	44
Malaysia	1.73	1.05	0.69	60.7	39.9	0.28	0.53	-0.25	191	-91
Brunei	-1.03	1.15	-2.18	-111.7	211.7	-2.49	0.63	-3.12	-25.4	125.4
China & India										
China	8.19	4.75	3.44	58.0	42.0	6.73	4.23	2.5	62.9	37.1
India	5.65	2.72	2.93	48.1	51.9	4.19	2.2	2	52.4	47.6
Memorandums										
The US	1.46	0.52	0.94	35.6	64.4	0	0	0	---	---

Source: Authors, calculated from data of Asian Productivity Organization and EU KLEMS.

4.2. Industry origin decomposition results

This subsection investigates the sources of labour productivity growth (LPG) and catch-up (Diff-in-LPG) using the industry origin decomposition framework. As presented in Appendices 1 and 2, one can quantify the sources from two angles: (i) pure productivity effect (PPE) vs. labour reallocation effect (LRE) and (ii) the contribution by individual sectors.

4.2.1. Contribution to labour productivity growth and catch-up: Pure productivity effect (PPE) vs. labour reallocation effect (LRE)

From the framework in Eq (A3) (Appendix 1), LPG is decomposed into PPE (Eq (3.1)), which sums up the pure productivity effect contributed by within-sector labour productivity growth, and LRE (Eq (3.2)), which captures the contribution of the labour reallocation effect in the economy. Similarly, from the framework in Eq (A7) (Appendix 2), the differential in LPG (Diff-in-LPG) is decomposed into the differential in PPE (Diff-in-PPE) and the differential in LRE (Diff-in-LRE). The decomposition results, which are reported in Table 6, reveal the following findings.

First, both PPE and LRE have a sizable share in driving LPG in ASEAN countries except for Brunei, Malaysia and Singapore. Specifically, the shares of PPE and LRE are both close to 50 per cent for Indonesia (48.4 per cent vs. 51.6 per cent); Cambodia (40.9 per cent vs. 59.1 per cent); Myanmar (53.6 per cent vs. 46.4 per cent); and Vietnam (49.4 per cent vs. 50.6 per cent). The share of PPE is significantly larger than that of LRE for Laos (70.4 per cent vs. 29.6 per cent); the Philippines (78.3 per cent vs. 21.7 per cent); and Thailand (66.5 per cent vs. 33.5 per cent). These results support the finding by van Ark and Timmer (2003) and Felipe et al. (2009) that resource reallocation is a powerful source of labour productivity growth for lower income countries in Asia.

Second, LRE plays an insignificant role in driving labour productivity growth of advanced ASEAN countries, namely Brunei, Malaysia, and Singapore. With Malaysia, LRE contributed only 0.07 ppts to LPG, accounting for a minor share 4.3 per cent. For Singapore, while PPE is positive and sizable with a contribution of 2.17 ppts, LRE is negative (-0.06 ppts). The case of Brunei is exceptional in that both PPE and LRE are negative and have a sizeable impact on the country's labour productivity contraction.

For comparison, both PPE and LRE make a significant positive contribution to LPG for China and India. Furthermore, PPE plays a dominant role, with its share in LPG amounting to 89.1 per cent for China and 82.3 per cent for India.

Third, both Diff-in-PPE and Diff-in-LRE are positive contributors to Diff-in-LPG for ASEAN countries, with the exceptions of Brunei and Indonesia. For Indonesia, its Diff-in-PPE is negative at -0.44 ppts although its PPE is positive. This means that Indonesia is behind the US in PPE, which makes this source a negative contributor to the country's labour productivity catch-up performance. This finding supports the conclusion by Kucera and Jiang (2019) about the essential importance of within-sector productivity improvement in driving overall labour productivity growth.

For comparison, both China and India far outperform the US in both PPE and LRE (Diff-in-PPE=5.77 ppts and Diff-in-LRE= 0.96 ppts for China; Diff-in-PPE=3.13 ppts and Diff-in-LRE= 1.06 ppts for India). In addition, Diff-in-PPE plays a major role in driving Diff-in-LPG (85.7 per cent for China and 74.6 per cent for India).

Table 6. Sources of ASEAN countries' labour productivity growth and catch-up, 1997-2017: Industry origin decomposition – Pure productivity effect vs. Labour reallocation effect

Economy	LPG and sources					Diff-in-LPG and sources				
	ppts			LPG=100		ppts			Diff-in-LPG=100	
	LPG	PPE	LRE	PPE	LRE	Diff-in-LPG	Diff-in-PPE	Diff-in-LRE	Diff-in-PPE	Diff-in-LRE
Brunei	-1.03	-0.39	-0.63	38.3	61.7	-2.49	-1.92	-0.57	77.1	22.9
Cambodia	4.39	1.79	2.59	40.9	59.1	2.93	0.27	2.66	9.3	90.7
Indonesia	2.24	1.09	1.16	48.4	51.6	0.79	-0.44	1.22	-55.2	155.2
Laos	4.63	3.26	1.37	70.4	29.6	3.17	1.74	1.43	54.8	45.2
Malaysia	1.73	1.66	0.07	95.7	4.3	0.28	0.14	0.14	49.5	50.5
Myanmar	7.81	4.18	3.62	53.6	46.4	6.35	2.66	3.69	41.9	58.1
Philippines	2.63	2.06	0.57	78.3	21.7	1.18	0.54	0.64	45.9	54.1
Singapore	2.10	2.17	-0.06	103.0	-3.0	0.65	0.64	0.00	99.8	0.2
Thailand	2.87	1.91	0.96	66.5	33.5	1.41	0.39	1.03	27.4	72.6
Vietnam	4.08	2.02	2.07	49.4	50.6	2.63	0.50	2.13	19.0	81.0
China & India										
China	8.19	7.30	0.89	89.1	10.9	6.73	5.77	0.96	85.7	14.3
India	5.65	4.65	1.00	82.3	17.7	4.19	3.13	1.06	74.6	25.4
Memorandums										
The US	1.46	1.52	-0.07	104.5	-4.5	0.00	0.00	0.00	---	---

Note: LPG=Labor Productivity Growth; PPE=Pure Productivity Effect; LRE=Labor Reallocation Effect.
Source: Authors, calculated from data of Asian Productivity Organization and EU KLEMS.

4.2.2. *Contribution by individual sectors to labour productivity growth and catch-up via pure productivity effect*

This examination is focused on the contribution of individual sectors to labour productivity growth (LPG) via pure productivity effect (PPE) and to the catch-up on labour productivity performance (Diff-in-LPG) via the differential in PPE (Diff-in-PPE).

As described in Appendix 3, for a given country, the economy can be grouped into night sectors, which include five production sectors (Agriculture; Mining; Manufacturing; Utilities; and Construction) and four services sectors (Trade, repairs, hotels, and restaurants; Transport and telecommunications; Finance, real estate, and business support; and Public and social services).

Labor productivity growth via pure productivity effect: Contribution by individual sectors

Tables 7A and 7B report the contribution by sectors to LPG via PPE, for which the decomposition results are derived from Eq (A3.1) (Appendix 1). The following findings are notable.

First, the total share in PPE of the production sectors is notably larger than that of the services sectors for all ASEAN countries, especially for Cambodia (96.1 per cent), Laos (86.5 per cent), Myanmar (84.9 per cent), and Vietnam (87.1 per cent). That is, the production sectors together play a major role in determining PPE.

Second, manufacturing makes a positive and sizable contribution to PPE in ASEAN countries, except for Brunei, ranging from 0.26 ppts for Laos to 1.11 ppts for Singapore. This sector is the largest contributor for Singapore (51.4 per cent), Malaysia (45.8 per cent), the Philippines (36.4 per cent), and Thailand (33.5 per cent).

Third, agriculture makes a positive and considerable contribution to PPE in ASEAN countries, except for Brunei and Singapore, ranging from 0.21 ppts for Malaysia to 1.26 ppt for Cambodia. In addition, this sector is the largest contributor for Cambodia (70.4 per cent), Vietnam (45.0 per cent), and Indonesia (34.9 per cent).

Fourth, mining is the largest contributor to LPG in terms of share in PPE for Myanmar (41.9 per cent) and Laos (35 per cent). It is worth mentioning that Laos' large investment in its hydropower plants, which export electricity to neighboring countries[11], has made its utility sector a large contributor to LPG, accounting for nearly one-fifth of its PPE.

Finally, the contribution of the services sectors to PPE tends to be stronger in higher income countries on two measures: (i) the aggregate contribution of the services group is large, and (ii) the contribution of each individual services sector is positive. These observations are clear for three higher income countries – Singapore, Malaysia, and Thailand. In contrast, four lower income countries, Cambodia, Laos, Myanmar, and Vietnam, tend to have weaker performance according to these two measures, especially if the contribution of public and social services sector is excluded.

With regard to China and India, while both production and services have substantial roles in PPE, the patterns differ: production group has a greater share in PPE for China (60.8 per cent), while services group is stronger for India (58.8 per cent). China and India exhibit a broad-based pattern of the contribution of production sectors to PPE, with all the sectors making a positive contribution. Manufacturing is the leading contributor in terms of share in PPE (35.3 per cent for China and 19.8 per cent for India), followed by agriculture (11.8 per cent for China and 14.9 per cent for India). It is interesting to note that manufacturing is also the leading contributor for the US, with a share of 35.5 per cent in PPE.

The services sectors exhibit a stronger performance in China and India than in ASEAN countries on two measures. First, the aggregate contribution of the services group for China (2.86 ppts) and India (2.73 ppts) is far larger than that of any ASEAN nation. Second, all the services sectors of China and India are positive contributors.

[11] Laos has formulated the strategy to boost its electricity export capacity to 14,800 MW by 2025, including 9,000 MW to Thailand, 5,000 MW to Vietnam, 500 MW to Myanmar, 200 MW to Cambodia, and 100 MW to Malaysia. Source: "Laos eyes being a transmission hub by 2025", 20 Feb 2019, Asian Power; available at https://asian-power.com/power-utility/news/laos-eyes-being-transmission-hub-2025, accessed March 20, 2020.

Table 7A. The contribution by sector to labour productivity growth via pure productivity effect (ppts), 1997-2017

Economy	PPE	Contribution by production sectors						Contribution by services sectors				
		PROD	Agr	Min	Mfg	Uti	Con	SERV	Trade-Hotel	Trans-Tel	Fin-Bserv	Pub-Soc
Brunei	**-0.39**	**-1.11**	-0.02	-0.86	-0.13	0.01	-0.1	**0.72**	-0.07	0.01	0.22	0.56
Cambodia	**1.79**	**1.72**	1.26	0.07	0.59	-0.01	-0.18	**0.07**	-0.08	0.04	0.04	0.07
Indonesia	**1.09**	**0.64**	0.38	-0.09	0.29	0.05	0.01	**0.45**	0.19	0.62	-0.55	0.18
Laos	**3.26**	**2.82**	0.65	1.14	0.26	0.64	0.13	**0.44**	0.47	0.17	-0.33	0.13
Malaysia	**1.66**	**0.85**	0.21	-0.29	0.76	0.12	0.04	**0.81**	0.2	0.23	0.01	0.37
Myanmar	**4.18**	**3.55**	0.86	1.75	0.36	0.05	0.53	**0.63**	-0.08	0.01	0.06	0.64
Philippines	**2.06**	**1.32**	0.29	0.03	0.75	0.17	0.09	**0.74**	0.4	0.17	0.05	0.12
Singapore	**2.16**	**1.23**	-0.01	0	1.11	0.07	0.06	**0.93**	0.52	0.23	0.14	0.04
Thailand	**1.91**	**1.17**	0.28	0.05	0.64	0.16	0.04	**0.74**	0.18	0.36	0.14	0.07
Vietnam	**2.02**	**1.76**	0.91	0.18	0.51	0.15	0.02	**0.26**	0.35	0.18	-0.5	0.23
China & India												
China	**7.3**	**4.44**	0.86	0.36	2.58	0.22	0.42	**2.86**	0.72	0.5	0.74	0.89
India	**4.64**	**1.91**	0.69	0.08	0.92	0.16	0.07	**2.73**	0.78	0.48	0.62	0.85
Memorandums												
The US	**1.52**	**0.57**	0.03	0.03	0.54	0.02	-0.05	**0.95**	0.25	0.44	0.26	0

Note: PPE=Pure Productivity Effect; LRE=Labor Reallocation Effect; The PROD group consists of five production sectors: Agr, Min, Mfg, Uti, and Con; The SERV group comprises four services sectors: Trade-Hotel, Trans-Tel, Fin-Bserv, and Pub-Soc.
Source: Authors, calculated from data of Asian Productivity Organization and EU KLEMS.

Table 7B. The contribution by sector to labour productivity growth via pure productivity effect (PPE=100), 1997-2017

Economy	PPE	Contribution by production sectors						Contribution by services sectors				
		PROD	Agr	Min	Mfg	Uti	Con	SERV	Trade-Hotel	Trans-Tel	Fin-Bserv	Pub-Soc
Brunei	**100**	**284.6**	5.1	220.5	33.3	-2.6	25.6	**-184.6**	17.9	-2.6	-56.4	-143.6
Cambodia	**100**	**96.1**	70.4	3.9	33	-0.6	-10.1	**3.9**	-4.5	2.2	2.2	3.9
Indonesia	**100**	**58.7**	34.9	-8.3	26.6	4.6	0.9	**41.3**	17.4	56.9	-50.5	16.5
Laos	**100**	**86.5**	19.9	35	8	19.6	4	**13.5**	14.4	5.2	-10.1	4
Malaysia	**100**	**51.2**	12.7	-17.5	45.8	7.2	2.4	**48.8**	12	13.9	0.6	22.3
Myanmar	**100**	**84.9**	20.6	41.9	8.6	1.2	12.7	**15.1**	-1.9	0.2	1.4	15.3
Philippines	**100**	**64.1**	14.1	1.5	36.4	8.3	4.4	**35.9**	19.4	8.3	2.4	5.8
Singapore	**100**	**56.9**	-0.5	0	51.4	3.2	2.8	**43.1**	24.1	10.6	6.5	1.9
Thailand	**100**	**61.3**	14.7	2.6	33.5	8.4	2.1	**38.7**	9.4	18.8	7.3	3.7
Vietnam	**100**	**87.1**	45	8.9	25.2	7.4	1	**12.9**	17.3	8.9	-24.8	11.4
China & India												
China	**100**	**60.8**	11.8	4.9	35.3	3	5.8	**39.2**	9.9	6.8	10.1	12.2
India	**100**	**41.2**	14.9	1.7	19.8	3.4	1.5	**58.8**	16.8	10.3	13.4	18.3
Memorandums												
The US	**100**	**37.5**	2	2	35.5	1.3	-3.3	**62.5**	16.4	28.9	17.1	0

Note: PPE=Pure Productivity Effect; LRE=Labor Reallocation Effect; The PROD group consists of five production sectors: Agr, Min, Mfg, Uti, and Con; The SERV group comprises four services sectors: Trade-Hotel, Trans-Tel, Fin-Bserv, and Pub-Soc.
Source: Authors, calculated from data of Asian Productivity Organization and EU KLEMS.

Labor productivity catch-up via pure productivity effect: Contribution by individual sectors

Tables 8A and 8B report the contribution by sectors to Diff-in-LPG via Diff-in-PPE, for which the results are decomposed from Eq (A8) (Appendix 2). The following findings stand out.

First, with the exception of Brunei, the differential in production group is positive for all ASEAN countries, ranging from 0.07 ppts for Indonesia to 2.98 ppts for Myanmar, while the differential in services group is negative for all ASEAN countries. That is, the production group plays a decisive role in enhancing ASEAN countries' catch-up performance through PPE, while the services group is a hindrance.

For comparison, both production and services group are positive and have substantial shares for China and India. However, production group plays a larger role (with a share of 67.1 per cent) for China, while services group claims a leading share (57.1 per cent) for India.

Second, though the contribution of the production group is positive for all countries except for Brunei, this pattern is broad-based only for the Philippines and Thailand, where all production sectors make a positive contribution. The remaining ASEAN countries experience a negative contribution by at least one production sector. In particular, the contribution of manufacturing is negative for four ASEAN countries: Indonesia (-0.25 ppts); Laos (-0.28 ppts); Myanmar (-0.19 ppts); and Vietnam (-0.03 ppts). This finding tends to suggest the slow labour productivity growth in the manufacturing sectors of these countries, which have been largely driven by labour-intensive industries.

Third, the leading sector with positive contribution is either agriculture or manufacturing for most countries. The leading sector is agriculture for Cambodia (with a share of 451.9 per cent), Indonesia (-77.3 per cent)[12], the Philippines (46.3 per cent), Thailand (61.5 per cent), and Vietnam (174.0 per cent); manufacturing for Malaysia (157.1 per cent) and Singapore (89.1 per cent); and mining for Myanmar (64.7 per cent) and Laos (63.8 per cent).

[12] Because Indonesia's Diff-in-PPE is negative (-0.44 ppts), the positive contributions of its agriculture sector has a negative share.

Finally, public and social services sector is the only sector that makes a positive contribution in all ASEAN countries, while finance, real estate and business support sector is a negative contributor in all ASEAN countries. During the period, while Laos, the Philippines, Singapore, and Vietnam are the four countries for which trade and hotel sector is a positive contributor, Indonesia is the only ASEAN economy whose transport and telecommunications sector makes a positive contribution.

Table 8A. The contribution by sector to labour productivity catch-up via differential in pure productivity effect (ppts), 1997-2017

Economy	Diff-in-PPE	Contribution by production sectors						Contribution by services sectors				
		PROD	Agr	Min	Mfg	Uti	Con	SERV	Trade-Hotel	Trans-Tel	Fin-Bserv	Pub-Soc
Brunei	**-1.91**	**-1.68**	-0.06	-0.89	-0.67	-0.01	-0.05	**-0.23**	-0.32	-0.44	-0.04	0.56
Cambodia	**0.27**	**1.15**	1.22	0.04	0.05	-0.03	-0.13	**-0.88**	-0.33	-0.4	-0.22	0.07
Indonesia	**-0.44**	**0.07**	0.34	-0.11	-0.25	0.03	0.06	**-0.51**	-0.06	0.18	-0.81	0.18
Laos	**1.74**	**2.25**	0.62	1.11	-0.28	0.62	0.18	**-0.51**	0.22	-0.27	-0.6	0.13
Malaysia	**0.14**	**0.28**	0.18	-0.31	0.22	0.1	0.09	**-0.14**	-0.05	-0.21	-0.25	0.37
Myanmar	**2.66**	**2.98**	0.83	1.72	-0.19	0.04	0.58	**-0.32**	-0.33	-0.43	-0.2	0.64
Philippines	**0.54**	**0.75**	0.25	0	0.21	0.15	0.14	**-0.21**	0.16	-0.28	-0.21	0.13
Singapore	**0.64**	**0.66**	-0.04	-0.03	0.57	0.06	0.11	**-0.02**	0.27	-0.21	-0.12	0.04
Thailand	**0.39**	**0.6**	0.24	0.02	0.1	0.14	0.09	**-0.21**	-0.07	-0.08	-0.12	0.07
Vietnam	**0.5**	**1.19**	0.87	0.15	-0.03	0.13	0.07	**-0.69**	0.1	-0.26	-0.76	0.23
China & India												
China	**5.77**	**3.87**	0.83	0.33	2.04	0.2	0.47	**1.9**	0.47	0.06	0.48	0.89
India	**3.12**	**1.34**	0.66	0.05	0.38	0.14	0.12	**1.78**	0.53	0.04	0.36	0.85

Note: PPE=Pure Productivity Effect; LRE=Labor Reallocation Effect; The PROD group consists of five production sectors: Agr, Min, Mfg, Uti, and Con; The SERV group comprises four services sectors: Trade-Hotel, Trans-Tel, Fin-Bserv, and Pub-Soc.

Source: Authors, calculated from data of Asian Productivity Organization and EU KLEMS.

Table 8B. The contribution by sector to labour productivity catch-up via differential in pure productivity effect (Diff-in-PPE=100), 1997-2017

Economy	Diff-in-PPE	Contribution by production sectors						Contribution by services sectors				
		PROD	Agr	Min	Mfg	Uti	Con	SERV	Trade-Hotel	Trans-Tel	Fin-Bserv	Pub-Soc
Brunei	**100**	**88**	3.1	46.6	35.1	0.5	2.6	**12**	16.8	23	2.1	-29.3
Cambodia	**100**	**425.9**	451.9	14.8	18.5	-11.1	-48.1	**-325.9**	-122.2	-148.1	-81.5	25.9
Indonesia	**100**	**-15.9**	-77.3	25	56.8	-6.8	-13.6	**115.9**	13.6	-40.9	184.1	-40.9
Laos	**100**	**129.3**	35.6	63.8	-16.1	35.6	10.3	**-29.3**	12.6	-15.5	-34.5	7.5
Malaysia	**100**	**200**	128.6	-221.4	157.1	71.4	64.3	**-100**	-35.7	-150	-178.6	264.3
Myanmar	**100**	**112**	31.2	64.7	-7.1	1.5	21.8	**-12**	-12.4	-16.2	-7.5	24.1
Philippines	**100**	**138.9**	46.3	0	38.9	27.8	25.9	**-38.9**	29.6	-51.9	-38.9	24.1
Singapore	**100**	**103.1**	-6.3	-4.7	89.1	9.4	17.2	**-3.1**	42.2	-32.8	-18.8	6.3
Thailand	**100**	**153.8**	61.5	5.1	25.6	35.9	23.1	**-53.8**	-17.9	-20.5	-30.8	17.9
Vietnam	**100**	**238**	174	30	-6	26	14	**-138**	20	-52	-152	46
China & India												
China	**100**	**67.1**	14.4	5.7	35.4	3.5	8.1	**32.9**	8.1	1	8.3	15.4
India	**100**	**42.9**	21.2	1.6	12.2	4.5	3.8	**57.1**	17	1.3	11.5	27.2

Note: PPE=Pure Productivity Effect; LRE=Labor Reallocation Effect; The PROD group consists of five production sectors: Agr, Min, Mfg, Uti, and Con; The SERV group comprises four services sectors: Trade-Hotel, Trans-Tel, Fin-Bserv, and Pub-Soc.

Source: Authors, calculated from data of Asian Productivity Organization and EU KLEMS.

5. A summary of results and concluding remarks

The paper reveals a number of important findings. First, all ASEAN countries, with the exception of Brunei, registered strong catch-up performance and solid convergence in per capita income over the period 1997-2017. This performance, however, does not necessarily guarantee the future prosperity of the region, as some if not many ASEAN countries, after a period of relatively rapid growth, may face the challenge of slow transition during their middle income years ahead (Felipe, Kumar and Galope 2017).

Second, growth in both labour productivity and labour participation make substantial contributions to the catch-up performance of ASEAN countries, with the exception of Brunei. In addition, for ASEAN's higher income countries (Singapore, Brunei, and Malaysia), growth in labour participation appears to make a stronger contribution to catch-up performance in income, suggesting the importance of immigrant labour in sustaining economic growth.

Third, capital deepening plays a leading role in driving growth in labour productivity and catch-up performance in all ASEAN countries. TFP growth, however, is not strong enough to be a meaningful contributor to catch-up performance in labour productivity for four ASEAN countries – Brunei, Indonesia, Malaysia, and Vietnam.

Fourth, the pure productivity effect (PPE) and labour reallocation effect (LRE) both play a substantial role in driving labour productivity growth in ASEAN countries except for Brunei, Singapore and Malaysia. With regard to catch-up in labour productivity, the differentials in PPE and in LRE are positive contributors, with the exceptions of Brunei and Indonesia. It should be noted that Indonesia's weak PPE is caused by the poor productivity performance of two major production industries – manufacturing and mining.

Fifth, among all production sectors, manufacturing is the only sector that makes a significant contribution to LPG (via PPE) across ASEAN countries, while agriculture and mining play a greater role in some countries (e.g., agriculture in Cambodia and Vietnam, and mining in Myanmar). Agriculture also made significant contribution to the differential in PPE for all ASEAN countries except for Brunei and Singapore. For services sectors, public services, social services, and transport and telecommunication are all positive contributors to LPG (via PPE) for all

ASEAN countries. However, the remaining two services sectors are negative contributors for some countries (e.g., trade-hotel in Brunei, Cambodia, and Myanmar; and finance-business services in Indonesia, Laos, and Vietnam). Furthermore, finance-business services is a negative contributor to the differential in PPE for all ASEAN countries. This is explainable because the US is far ahead of most ASEAN countries in financial sector development.

Six and finally, examining similar results for China and India reveals that these two economies generally have more robust performance than ASEAN countries on two measures: magnitude of catch-up and robustness of the contribution pattern of sectors (in which all sources are positive contributors).

These findings can be combined with related insights from existing studies to draw several policy implications for enhancing the effectiveness of economic catch-up efforts in ASEAN countries.

First, ASEAN countries should avoid bias towards capital accumulation as the dominant mechanism to boost economic growth, focusing instead on strategic measures around TFP growth based on quality human capital and innovation. As observed from the case of Vietnam, the shift of priority from capital accumulation to innovation requires resources and institutional arrangements with clear mandate and commitment for effectively coordinating efforts to promote technology acquisition and innovation (Klingler-Vidra and Wade 2020).

Second, all countries should prioritize efforts to promote within-sector labour productivity growth in order to boost overall labour productivity via the PPE.[13] This calls for more effective exploitation of the "backwardness advantage" and stronger strategic support for acquisition of knowledge and innovation in the rapidly changing environment. On this endeavor, human capital development (Guarini, Molini and Rabellotti 2007) and ICT penetration (Vu and Asongu 2020) play a powerful role.

[13] Timmer and de Vries (2009) find that accelerated growth is explained by productivity increases within sectors rather than by reallocation of employment to more productive sectors.

Third, robustly maintaining structural change plays a substantial role in driving labour productivity growth (Rodrik 2013; Vu 2017). However, as a country's income rises, the growth effect of basic structural change such as reallocation of labour from agriculture to manufacturing and services sectors diminishes. In such situations, a country should adopt a more sophisticated strategies to foster structural change, continually reallocating production factors (e.g., labour, capital, and land) to higher-value activities across all sectors and firms.

Fourth, promoting within-sector labour productivity growth (PPE) should go beyond production sectors to ensure that services sectors increase their contributions to economic catch-up. For these efforts, Jorgenson and Timmer (2011) suggest that greater attention to individual service sectors enhances policymakers' understandings about the process of economic growth and structural change, potentially generating the conditions for formulating more effective development strategies.

Fifth and finally, ASEAN countries can substantially boost economic growth and catch-up through deeper regional integration and policy coordination, leveraging their advantages in scale and strategic location amidst the rise of Asia. As the catch-up dynamics among ASEAN countries become vibrant as seen for the past two decades (1997-2017), one may expect that the convergence trend will be even more solid in the next two-three decades. The integration efforts should aim to generate cross-country spill-over effects, knowledge sharing, and structural change, which have been proved beneficial for growth and convergence (Conley and Ligon 2002; Gennaioli et al. 2014). It should also be noted that the favorable geographic conditions of ASEAN countries need effective strategy to become a strategic driver of long-term growth. Otherwise, they could become hindrances to human capital development required for building institutions and other factors essential to the pace of industrialization (Galor and Moav 2000).

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Appendix 1: Frameworks for decomposing the sources of growth

Primary sources of per capita income growth

For a given country, the per capita income growth (INCG) over a period can be decomposed as:[14]

$$\Delta lny = \Delta \ln(Y/P) = \Delta lnY - \Delta lnP = [\Delta lnY - \Delta lnE] + [\Delta lnE - \Delta lnP]$$

$$= \Delta \ln q + \Delta lne \quad \text{(A1)}$$

where $\Delta \ln$ in front of a variable denotes its growth rate over the period of question; Y indicates GDP, P indicates population, and $y = Y/P$ represents per capita income; E is the total number of employed persons in the economy; $q = Y/E$ expresses labour productivity[15]; and $e = E/P$ denotes the employment-to-population ratio, a measure of labour participation[16].

The decomposition framework from Eq (A1) suggests that a country's per capita income growth (INCG) over a period originates from two sources:

- Labor productivity growth (LPG), $\Delta \ln q$, and
- Employment-to-population ratio growth (E2PC), $\Delta \ln e$.

Sources of labour productivity growth

The labour productivity growth, $\Delta \ln q$, in turn, can be further decomposed using two different decomposition methods: growth accounting and industry origin. Using both of these decomposition approaches provides complementary and rich insights into the sources of economic growth and catch-up for a given country.

<u>Growth accounting approach</u>

[14] The subscripts of country i over period $[0, T]$ are suppressed for exposition simplicity.
[15] Due to data availability, the number of workers instead of hours worked is used to capture employment.
[16] Note that this definition of the employment-to-population ratio is used to make it relevant for this analysis of per capita income growth. A standard definition of the employment-to-population ratio uses the working age population.

Following Jorgenson, Ho and Stiroh (2005) and Jorgenson and Timmer (2011)[17], labour productivity growth, Δlnq, can be decomposed based on a growth accounting framework as follows:

$$\Delta lnq = \bar{v}\Delta lnk + \Delta lnA \qquad \text{(A2)}$$

where $\bar{v} = 0.5 * (v_0 + v_T)$ is the period average income share of capital for period $[0, T]$; k is the capital deepening measured as total capital services K divided by the number of workers E ($k = K/E$); and ΔlnA is total factor productivity growth.

Applying the decomposition framework from Eq (A2), the labour productivity growth of a given economy can be decomposed into two main sources:

- The contribution of capital deepening (kCon):
  $\text{kCon} = \bar{v}\Delta lnk$ (A2.1)
  and
- Total factor productivity growth (TFPG):
  $\text{TFPG} = \Delta lnA$ (A2.2)

Industry origin approach

Following the industry origin approach, labour productivity growth, Δlnq, can be decomposed into the contribution by economic sector and the labour reallocation effect across sectors. Following Stiroh (2002) and Jorgenson, Mun and Stiroh (2005), labour productivity growth can be decomposed as follows:

$$\Delta lnq = \Delta lnY - \Delta lnE = \sum_{j=1}^{m} \overline{w}_j \Delta lnVA_j - \Delta lnE = \sum_{j=1}^{m} \left[\overline{w}_j \Delta lnq_j + \overline{w}_j \Delta lnE_j\right] - \Delta lnE$$

$$= \sum_{j=1}^{m} \overline{w}_j \Delta lnq_j + \left[\sum_{j=1}^{m} \overline{w}_j \Delta lnE_j - \Delta lnE\right] \qquad \text{(A3)}$$

where Y is GDP and E is the total number of workers as defined in Eq (A1); *m* is the number of constituent sectors of the economy; VA_j is the value-added generated by sector j and E_j is its

[17] Due to data unavailability, this simplified framework does not quantify the quality of capital and labour separately.

number of workers; q_j is the sector's labour productivity; and $\overline{w}_j$ is the period-average of its share in GDP.

Based on Eq (A3), labour productivity growth can be decomposed into two main sources:

- The contribution of within-sector productivity growth, or the "pure productivity effect" (PPE) as termed by Nordhaus (2002):

$$PPE = \sum_{j=1}^{m} \overline{w}_j \Delta lnq_j \qquad \text{(A3.1)}$$

  and

- The labour reallocation effect (LRE):

$$LRE = \left[\sum_{j=1}^{m} \overline{w}_j \Delta lnE_j - \Delta lnE\right] \qquad \text{(A3.2)}$$

Appendix 2: Frameworks for decomposing the sources of economic catch-up

Primary sources of the catch-up performance in terms of per capita income

As presented in Section 3, the catch-up performance of a country in terms of per capita income is captured by its catch-up performance index (CUPI). The formula of the CUPI for country i during period [0, T], as defined in Eq (1), can be elaborated as:

$$CUPI_{0,T}^{i} = ln\left[\frac{rel_{y_T}{}^{i}}{rel_{y_0}{}^{i}}\right]/T * 100 = ln\left[\frac{\frac{y_T^i}{y_T^{US}}}{\frac{y_0^i}{y_0^{US}}}\right]/T * 100 = (\Delta lny_{0,T}^{i} - \Delta lny_{0,T}^{US}) * 100 \qquad \text{(A4)}$$

That is, the CUPI can also be seen as the differential in income growth (Diff-in-INCG) measured in percentage points between country i and the US.

Combining Eq (A4) with Eq (A1) yields:[18]

$$CUPI^{i} = \left(\Delta lnq^{i} - \Delta lnq^{US}\right) + (\Delta lne^{i} - \Delta lne^{US}) \qquad \text{(A5)}$$

Eq (A5) provides a simple framework for decomposing the CUPI into two primary sources concerning the differentials between country i and the US:

[18] The subscript of period $[0, T]$ is suppressed for exposition simplicity.

- The differential in labour productivity growth (Diff-in-LPG):
  $\left(\Delta lnq^{i} - \Delta lnq^{US}\right)$ (A5.1)
- The differential in the employment-to-population ratio growth (Diff-in-E2PC):
  $(\Delta lne^{i} - \Delta lne^{US})$ (A5.2)

The drivers of catch-up performance in terms of labour productivity

Similar to the sources of LPG, the differential in labour productivity growth $\left(\Delta lnq^{i} - \Delta lnq^{US}\right)$, in turn, can be broken down further using the growth accounting and industry origin analysis approaches.

Growth accounting framework

Applying the growth accounting decomposition framework specified in Eq (A2), the differential in productivity growth can be expressed as

$$\Delta lnq^{i} - \Delta lnq^{US} = (\bar{v}^{i}\Delta lnk^{i} - \bar{v}^{US}\Delta lnk^{US}) + (\Delta lnA^{i} - \Delta lnA^{US}) \quad \text{(A6)}$$

That is, the differential in productivity growth (Diff-in-LPG) between country i and the US can be decomposed into two main sources:

- The differential in the contribution of capital deepening (Diff-in-kCon):
  $(\bar{v}^{i}\Delta lnk^{i} - \bar{v}^{US}\Delta lnk^{US})$ (A6.1)
- The differential in TFP growth (Diff-in-TFPG):
  $\left(\Delta lnA^{i} - \Delta lnA^{US}\right)$ (A6.2)

Industry origin analysis

From Eq (A3), the differential in labour productivity growth can be expressed as

$$\Delta lnq^{i} - \Delta lnq^{US} = (PPE^{i} - PPE^{US}) + (LRE^{i} - LRE^{US}) \quad \text{(A7)}$$

That is, the Diff-in-LPG can be decomposed into two sources:

- The differential in the pure productivity effect (Diff-in-PPE):
  $(PPE^{i} - PPE^{US})$ (A7.1)

and

- The differential in labour reallocation effect (Diff-in-LRE):

$$(LRE^{i} - LRE^{US}) \qquad \text{(A7.2)}$$

From Eq (A3.1), the differential in PPE (Diff-in-PPE) can be expressed as

$$PPE^{i} - PPE^{US} = \sum_{j=1}^{m}[\overline{w}_j^i \Delta lnq_j^i - \overline{w}_j^{US} \Delta lnq_j^{US}] \qquad \text{(A8)}$$

Appendix 3: Data

The decomposition exercises applying the aforementioned frameworks use data from three sources: (i) the World Development Indicators (WDI) database, which provides data on GDP per capita measured in PPP$; (ii) the Asian Productivity Organization (APO) data set, which provides growth accounting and sector-level data for Asian countries[19]; and (iii) the EU KLEMS database, which provides growth accounting and sector-level data for the US[20].

Note that the EU KLEMS database is far more detailed and comprehensive than the APO data set. To make the APO and EU KLEMS data comparable, one needs to carry out two simple harmonizing steps.

First, for the growth accounting decomposition, the sources of LPG for the US from the EU KLEMS database are simplified to make them comparable to those for Asian countries from the APO data set. More specifically, the contributions of capital deepening from tangible non-ICT capital, tangible ICT capital, and intangible software are grouped into the contribution of capital deepening (kCon). Furthermore, the contributions to LPG from other sources, including intangible R&D, other intangible intellectual property rights, and labour composition, are attributed to TFP growth (TFPG).

Second, the industry origin decomposition framework relies on a set of nine aggregate economic sectors from the national account, as elaborated below, which include (i) Agriculture

[19] For a complete description of the data set, see Nomura and Lau (2019)
[20] For a complete description of the database, see Stehrer et al. (2019), Jäger (2017) and O'Mahony and Timmer (2009).

(Agr); (ii) Mining (Min); (iii) Manufacturing (Mfg); (iv) Utilities (Uti); (v) Construction (Con); (vi) Trade and hotels (Trade-Hotel); (vii) Transport and telecommunications (Trans-Tel); (viii) Finance, real estate, and business services (Fin-Bserv); and (ix) Public and social services (Pub-Soc). Among the nine sectors, five belong to the production group (PROD), which includes Agr, Min, Mfg, Uti, and Con; while the services group (SERV) comprises four sectors: Trade-Hotel, Trans-Tel, Fin-Bserv, and Pub-Soc.

The industry classification of the nine economic sectors

Sector	Sector's complete title	APO (ISIC Rev.3)	EU KLEMS (ISIC Rev.4)
1. Agriculture (Agr)	Agriculture, hunting, forestry, and fishing	01,02,05	A
2. Mining (Min)	Mining and quarrying	10-14	B
3. Manufacturing (Mfg)	Manufacturing	15-35	C
4. Utilities (Uti)	Electricity, gas and water supply	40-41	D-E
5. Construction (Con)	Construction	45	F
6. Trade, repairs, hotels, and restaurants (Trade-Hotel)	Wholesale and retail trade, repair of vehicles and household goods, hotels and restaurants	50-52,55	GI
7. Transport and telecommunications (Trans-Tel)	Transport, storage and communications	60-64	HJ
8. Finance, real estate, and business support (Fin-Bserv)	Financial intermediation, real estate, renting and business activities	65-67,70-74	KM-N
9. Public and social services (Pub-Soc)	Public, community, social and personal services	75,80,85,90-93,95,99	OPQR-S

Source: APO Productivity Databook 2019; EU KLEMS Growth and Productivity Accounts, 2017 Release – Description of Methodology and General Notes