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Growth Convergence and the Middle-Income Trap

TAKATOSHI ITO*

Emerging market economies in East Asia have followed a similar growth path (growth convergence) from a low-income, high-growth state to a middle-income, middle-growth state through industrialization. The economic development of Japan was followed by the "four tigers" (Hong Kong, China; the Republic of Korea; Singapore; and Taipei,China) in the 1970s; and subsequently by members of the Association of Southeast Asian Nations in the 1980s and the People's Republic of China in the 1990s and 2000s.

The growth rates of Asian economies are slowing over time and may fall to advanced economy levels before incomes fully catch up with the advanced economies. This is defined as the middle-income trap in the paper.

This paper proposes that there exist three convergence paths in Asia: low income, middle income, and high income. Economies need to shift from one convergence path to a higher one by implementing economic and political reforms that can generate innovation. Without reform, economies may fall into a low- or middle-income trap.

Keywords: Asian financial crisis, global financial crisis, growth convergence, middle-income trap
JEL codes: O11, O14, O33, O40

I. Introduction

Over the past several decades, East Asian economies have achieved higher economic growth rates than economies in other regions. These Asian economies have all followed a similar growth path (growth convergence) from a low-income, high-growth state to a middle-income, middle-growth state through industrialization. Among them, Japan and Singapore have reached advanced economy status. The economic development of Japan was first followed by the "four tigers" (Hong Kong, China; the Republic of Korea; Singapore; and Taipei,China) in the 1970s; and subsequently by members of the Association of Southeast Asian Nations (ASEAN) in the 1980s and the People's Republic of China (PRC) in the 1990s and 2000s.

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The history of economic development in Asia comprises several distinct stages. In the 1950s, Japan was already experiencing rapid growth of 10% annually. However, this was viewed as an isolated example of a prewar industrial powerhouse in Asia returning to the level of development it enjoyed before the devastation of the Second World War. Meanwhile, other Asian economies were still struggling to establish effective forms of government after gaining their independence from colonial powers.[1] Most Asian economies were characterized by populous urban areas with widespread poverty and stagnant agrarian sectors in rural areas. The most influential work at the time, Gunnar Myrdal's *Asian Drama*, offered a pessimistic view of the region's prospects for economic development. He argued that the burden of large populations, among other factors, was too great to overcome.

In the 1960s and 1970s, the "four tigers"—Hong Kong, China; the Republic of Korea; Singapore; and Taipei,China—experienced rapid and accelerating growth. Both the Republic of Korea and Singapore had strong governments that pursued industrial policy—government planning to encourage particular industries through zoning, subsidies, and the allocation of credit. These two economies increased their production and export of goods in sectors that Japanese industries had yielded in order to move to higher value-added goods. The success of the four tigers eventually prompted policy changes in Southeast Asian economies. Growth rates in Indonesia, Malaysia, and Thailand started to rise in the mid-1980s. As rapid growth spread to these ASEAN economies, Asia began attracting increased global attention. In 1993, the World Bank painted a very positive picture of East Asian industrialization, export-oriented policies, and equitable growth in *The East Asian Miracle*, which replaced *Asian Drama* as a representative view of the region.

The positive view of East Asia suffered a brief setback in the wake of the 1997/98 Asian financial crisis (AFC). The currency crises in East Asia—particularly in Indonesia, the Republic of Korea, and Thailand, all of which required International Monetary Fund assistance—were blamed on crony capitalism and excessive risk in the banking sector, among other factors. The image of manufacturing success was replaced by one of financial failure. However, most Asian economies experienced a V-shape recovery and learned valuable lessons from the experience. Banking sectors were reformed and foreign reserves were accumulated as a buffer against volatile capital flows. During the 2008–2009 global financial crisis (GFC), no Asian banks failed due to collapsing values for asset-backed securities and related financial products. The damage to East Asian growth during the GFC was much shallower than that endured during the AFC.

However, growth rates in Asian economies today are slowing down to those of advanced economy levels. A fear is that these economies will never catch up with the income levels of advanced economies and instead will be trapped in

[1]Most Asian economies were colonized by a European power, except for Thailand, which was never colonized, and the Philippines, which was colonized first by Spain and then by the United States (US).

middle-income status. Several factors contribute to this pessimism. Japan has experienced 2 decades of stagnation. At the same time, the PRC has excelled on all fronts of industry, leaving behind some of its neighboring economies that have not been able to similarly overcome constraints to growth such as a lack of infrastructure and human capital development.

In order to explain the long-run growth experiences of Asian economies in a more generalized framework, growth convergence regressions are applied. Growth theory predicts that a low-income state tends to record high growth and that the growth rate gradually becomes lower as the income level becomes higher. The inverse relationship between income level and the growth rate is often depicted as a downward-sloping convergence line. This relationship is derived from diminishing returns to capital. The convergence path has often been evident in time series data for individual economies, but it has been difficult to find in cross-section or panel data. Within a group of economies such as the Organisation for Economic Co-operation and Development, a common convergence path can be found. However, an attempt to find a global cross-sectional or panel relationship of convergence often fails. This is understandable since a global convergence path assumes that economies' production functions, including their technological level and productivity, are identical and the only difference is the initial level of capital (per capita). Therefore, an unconditional convergence is refuted easily. The literature instead favors conditional convergence that allows for differences in culture, geography, colonial heritage, and other socioeconomic variables as initial conditions. Hence, there can be different convergence lines for different groups of economies.

In the failed attempt to find unconditional convergence, East Asian economies show positive forecast errors, which means that East Asian economies recorded higher growth rates than South Asian, African, and Latin American economies at the same income levels. Hence, developing East Asian economies have moved toward advanced economy income levels much faster than economies in other regions. Although the "Asian Miracle" can be attributed to many factors, it remains untested whether East Asia as a region can be treated as one group and if the experiences across the region are common.

This paper focuses on growth convergence in East Asia. It looks at panel data for major economies in the region. The first test is whether they share a common, unconditional convergence path, which appears not to be the case. Instead, this paper finds three distinct convergence paths in East Asia: (i) one path that converges to a low-income steady state, (ii) another that converges to a middle-income steady state, and (iii) a third that converges to a high-income steady state. An economy can shift from one convergence line to a higher one by implementing economic reforms, such as the opening of the PRC's economy beginning in 1978 and Viet Nam's *doi moi* (reconstruction) policy launched in 1986. Without reform, an economy may end up in the poverty trap (steady state of the low-income convergence path) or the middle-income trap (steady state of the middle-income convergence path). Data suggest that the PRC is moving from a middle-income convergence path to a high-income path and that the Philippines is moving from a low-income path to a middle-income path. Thailand seems to be headed for the middle-income trap.

According to the hypothesis of three distinct convergence paths, the fear of being trapped in middle-income status can be understood as the policy failure to make a leap from one convergence line to a higher one. This leap requires economic reforms to stimulate innovation.

The rest of the paper is organized as follows. Section II reviews the growth performances of East Asian economies from 1985 to 2015. These economies suffered more during the AFC than during the subsequent GFC. Section III establishes that there is a long-run slowdown in the growth rate in almost all economies in East Asia. However, the slowdown may be perfectly natural if growth convergence is taking place. A crucial question is whether there is a common convergence path for all Asian economies and, if not, how many such paths exist.

Section IV establishes that in Asia there are three convergence paths: low income, middle income, and high income. Economies can and do jump from one convergence path to another by pursuing reforms and stimulating innovation. When an economy fails to jump from a middle-income convergence path to a high-income convergence path, it is said to be caught in the middle-income trap.

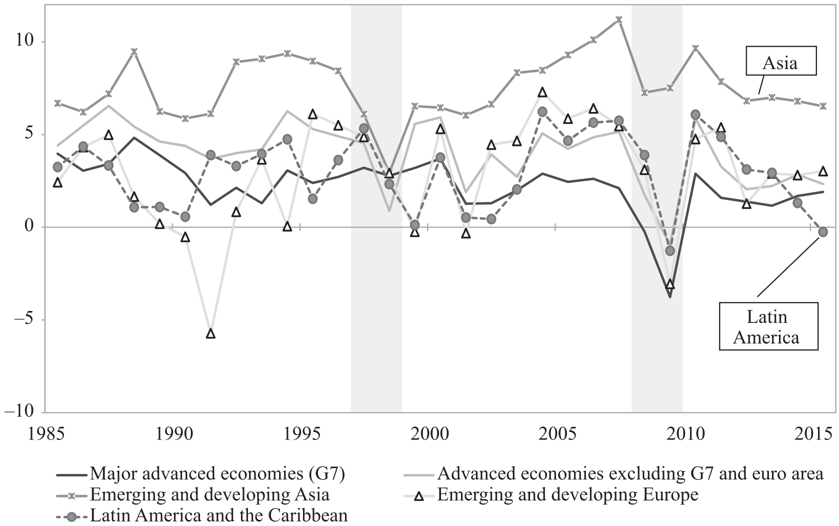
II. Impacts of the 1997/98 Asian Financial Crisis and the 2008–2009 Global Financial Crisis

The GFC had significant impacts on many economies and affected most severely the United States (US) and Europe. Asian economies suffered from negative spillovers from the advanced economies, but the negative impact on growth was much less than in other regions. This showed the economic resilience of the Asian region. For emerging Asia, the dip in growth rates during the GFC was much shallower than during the AFC. The severe impacts in Asia in 1997/98 were due to the fact that the crisis originated in some of the region's economies. Figure 1 presents time series data (1985–2015) for real gross domestic product (GDP) growth rates of various regions as defined by the International Monetary Fund. Figure 1 shows that Asia has consistently grown faster than other regions except during crisis periods, the most serious of which was the AFC.

Figure 2 presents time series data (1985–2015) for the growth rates of Japan and the four tigers (Hong Kong, China; the Republic of Korea; Singapore; and Taipei,China). The figure shows that the four tigers experienced larger dips in growth during the AFC than the GFC, while Japan exhibits the opposite pattern. In addition, the medium-term growth trends of the four tigers declined from the pre-AFC period (1985–1996) to the intercrises period (1999–2007), and again in the post-GFC period (2010–2015).

Figure 1. **Growth Rates: Asia versus Other Regions**

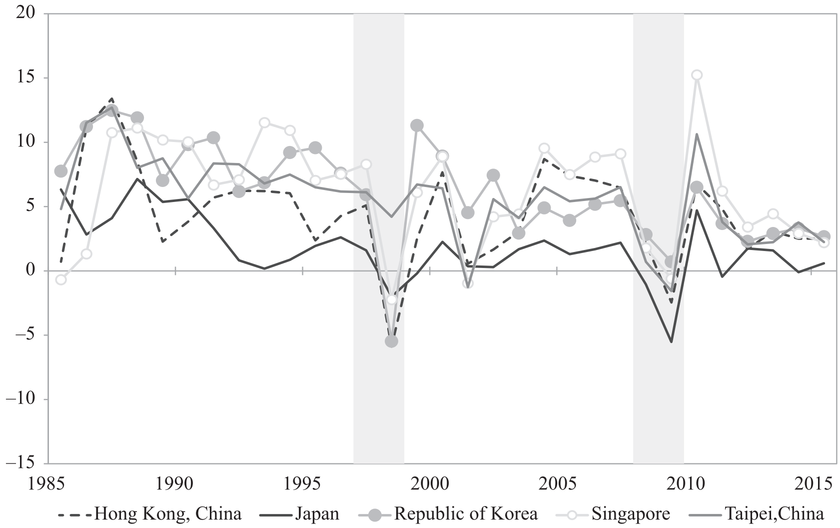
GDP, constant prices (year-on-year, % change)



GDP = gross domestic product.
Source: International Monetary Fund. *World Economic Database, October 2015*.
https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/download.aspx

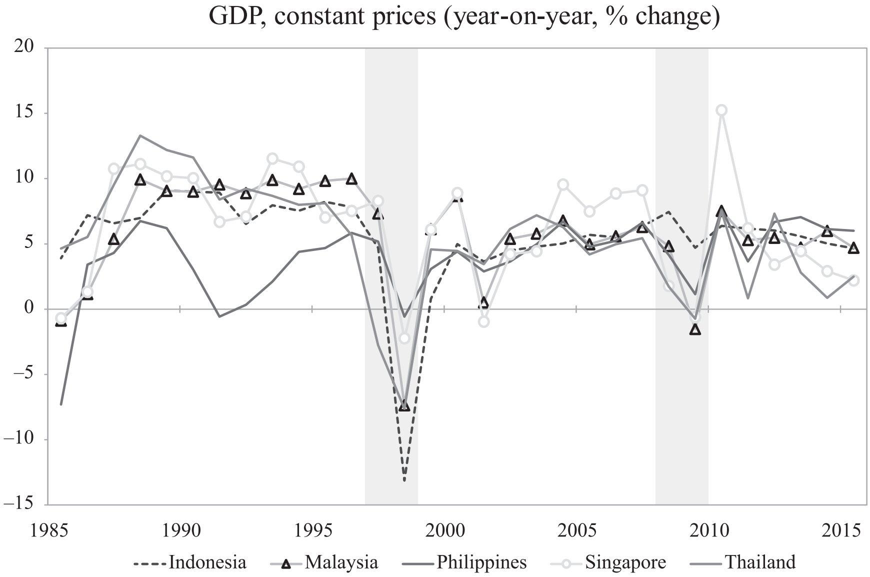
Figure 2. **Growth Rates of Japan and the "Four Tigers"**

GDP, constant prices (year-on-year, % change)



GDP = gross domestic product.
Source: International Monetary Fund. *World Economic Database, October 2015*.
https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/download.aspx

Figure 3. **Growth Rates of Members of the Association of Southeast Asian Nations**



GDP = gross domestic product.
Source: International Monetary Fund. *World Economic Database, October 2015*. https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/download.aspx

Since the PRC seems to dominate the economic statistics of emerging Asia, a decomposition of the region is necessary. Figure 3 presents growth rates over the same time period for the five original members of ASEAN, which are collectively referred to as ASEAN-5, to show a representative group from emerging Asia.[2] (Singapore appears both in Figure 2 and Figure 3.) A long-run growth slowdown between the 1980s and 2010s is evident. Annual growth of less than 5% in the 2010s has prompted concerns that Indonesia, Malaysia, and Thailand could fall into the middle-income trap. While the Philippines used to be at the bottom of the ASEAN-5 growth rankings, it has been the highest-performing economy among the ASEAN-5 in the first half of the 2010s. The Philippines' growth rate accelerated in the post-GFC period when other ASEAN economies, as well as advanced economies, experienced growth slowdowns. Over the same period, the growth rate of Singapore, despite its high per capita income, has been comparable to those of Indonesia, Malaysia, and Thailand. This implies that the income gap between Singapore and these other three economies has not yet narrowed and that they may not be on the same convergence path.

Figure 4 shows the growth patterns of the PRC and India in the 1985–2015 period. Under Deng Xiaoping, the PRC introduced major market-oriented reforms

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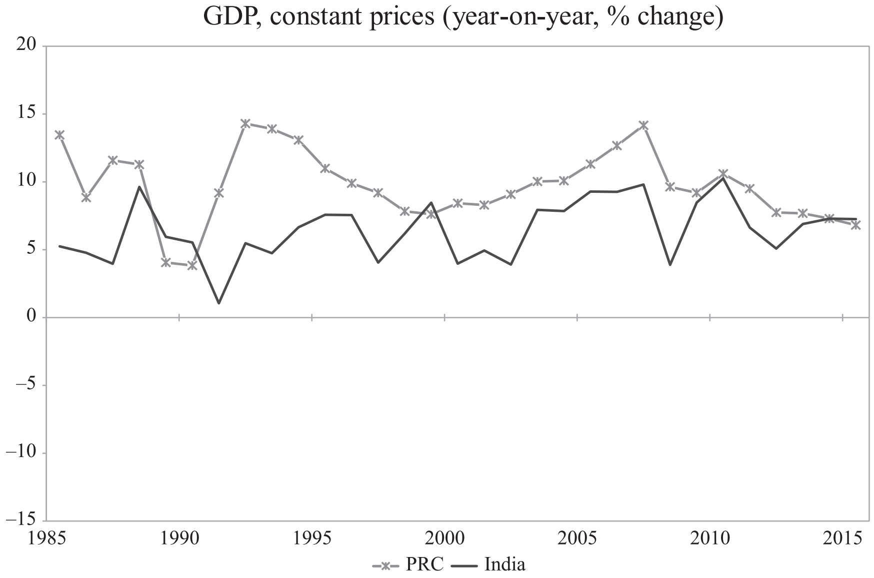
[2]ASEAN was established in August 1967 by Indonesia, Malaysia, the Philippines, Singapore, and Thailand.

Figure 4. **Growth Rates of the People's Republic of China and India**



GDP = gross domestic product.
Source: International Monetary Fund. *World Economic Database, October 2015*. https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/download.aspx

in 1978, including the privatization of many state-owned enterprises, that gradually opened its economy to the rest of the world. As a result, its growth rate accelerated rapidly in the 1980s before experiencing a large dip in 1989/90, which coincided with a decline in foreign direct investment (FDI) following the 1989 Tiananmen Square protests. Reforms continued after Deng Xiaoping's retirement in 1992. The Shanghai Stock Exchange was reopened in 1990 after a 41-year closure and multiple foreign exchange rates were unified in 1994. From 1991 through 2001, the PRC maintained a very high annual average growth rate of more than 10%. Only recently has the PRC's growth rate slowed, which is typical for any economy that has achieved 10% annual growth for 20 years.[3]

India's economic growth over the last 30 years has been consistently lower than that of the PRC, leading to a widening of the income gap between them. Rather than a convergence, there appears to be a divergence between the two economies. However, India's growth rate has accelerated since a balance of payment crisis in 1991 prompted widespread reforms that moved the economy away from socialism. Today, India continues to pursue a gradual reform process of privatization and the removal of regulatory barriers.

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[3] Japan also experienced an average annual growth rate that exceeded 10% during the 1950s and 1960s before slowing in the 1970s.

Table 1. **Period Average Growth Rates**
(%)

	Pre-AFC 1985–1996	**Intercrises 1999–2007**	**Post-GFC 2010–2015**
Hong Kong, China	4.8	4.7	2.2
Japan	2.8	1.4	0.9
Republic of Korea	8.2	4.8	2.5
Singapore	5.7	4.4	2.1
Taipei,China	7.1	4.3	2.5
Malaysia	5.5	3.3	3.5
Indonesia	5.9	3.6	4.0
Thailand	7.6	4.4	2.4
Philippines	1.3	3.0	4.0
Cambodia	NA	7.7	5.5
Lao PDR	2.2	5.1	5.8
Myanmar	NA	12.1	6.8
Viet Nam	4.8	5.9	4.8
PRC	8.6	9.8	7.3
India	3.6	5.4	5.0

AFC = Asian financial crisis, GFC = global financial crisis, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.
Source: Author's compilation.

III. Slowdowns in Growth

Since the GFC, many advanced economies have struggled to stimulate growth even with highly accommodative monetary policies and fiscal stimulus. Some economists have argued that advanced economies have entered a new phase marked by secular stagnation and a slower pace of technological innovation. Others regard the slowdown as a more normal process, considering that the GFC originated in the advanced economies. It has been commonly observed that economies in which crises originate suffer from dysfunctional financial markets that drag down real economic activity. Hence, the post-GFC slowdown in growth is not surprising.

Emerging market economies have also suffered a growth slowdown since the GFC. The PRC's growth rate slowed from 10% in 2010 to less than 7% in 2015. This has led to declines in global commodity prices that have affected a number of resource-producing economies. Other Asian economies have experienced a similar growth slowdown in the aftermath of the GFC.

Table 1 summarizes the average growth rates for three periods: pre-AFC (1985–1996), intercrises (1999–2007), and post-GFC (2010–2015). For most emerging East Asian economies, the post-GFC period saw growth below that of the intercrises period preceding the GFC, which also saw slower growth than during the pre-AFC period. Typically, the period average growth rates, g(period), of emerging Asian economies is as follows:

$$g(1985\text{–}1996) > g(1999\text{–}2007) > g(2010\text{–}2015)$$

Three notable exceptions to this stylized fact are India, the Lao People's Democratic Republic (Lao PDR), and the Philippines. These three economies experienced accelerating growth rates between the pre-AFC and intercrises periods, and again between the intercrisis and post-GFC periods. The reasons for these gains include improved macroeconomic policy management in the Philippines finally bearing fruit, while in the Lao PDR the increased exports of hydropower-generated electricity to Thailand is boosting economic growth.

Many policy makers and scholars view the postcrisis slowdown and stagnation among emerging economies as a stylized fact, while lamenting that growth rates have not yet recovered to their pre-GFC levels. More recently, policy makers in ASEAN-5 economies have expressed concern over the middle-income trap. Although their national income remains at upper-middle levels, their potential growth rates seem to have declined significantly since the GFC. Meanwhile, the PRC's industrial potential has caught up to ASEAN-5 levels, while innovation in ASEAN-5 economies seem to have failed in catching up with that of Japan, the Republic of Korea, and Singapore.

Yet, the middle-income trap is too easy an explanation for the slowdowns in growth observed in Table 1. The lingering effects of the GFC and the subsequent volatility in capital flows are also partially to blame, which is consistent with at least three other hypotheses for explaining declining growth rates in emerging East Asian economies: (i) postfinancial crisis slowdown, (ii) global secular stagnation, and (iii) growth convergence.

A postfinancial crisis slowdown is not a unique occurrence. Reinhart and Rogoff (2009, 2014) have argued that the median length of time needed to return to precrisis growth levels is about 6.5 years. In fact, "[5 to 6] years after the onset of crisis, only Germany and the US (out of 12 systemic cases) have reached their 2007–2008 peaks in real income" (Reinhart and Rogoff 2014, 50). This tendency can help explain the slowdown of growth in East Asian economies between the pre-AFC period and the intercrises period. However, it may not explain the slowdown between the intercrises period and the post-GFC period since Asia did not suffer a financial crisis during the GFC. Rather, the slowdown experienced during the GFC was transmitted through trade channels from advanced economies to Asia.

Another possibility for the Asian growth slowdown is that it is in line with global secular stagnation. Not only growth rates, but also inflation and real interest rates have been declining since the early 1990s (Bean et al. 2015). Asia may be suffering from a global lack of aggregate demand and a savings glut. Any explanations that are consistent with secular stagnation are most applicable to advanced economies. Hence, emerging Asian economies are unlikely experiencing a state of secular stagnation; that is, one in which persistent aggregate demand is less than aggregate supply.

The last explanation for the growth slowdown in emerging Asia is the theory of growth convergence. The stylized fact of slowing growth rates can be viewed as part of the process of convergence in addition to the lingering effects of a crisis.

IV. Growth Convergence

A. Concept of Growth Convergence

In the growth literature, the phenomenon known as convergence is theoretically predicted and empirically observed. Given common technology, the higher an economy’s income level, the slower its growth rate will become. Put differently, a low-income economy can grow faster than a high-income economy since the marginal contribution to the growth of capital accumulation is much higher among low-income economies. As the Appendix details, the typical convergence equation can be written as

$$g_j(t) = a + b\{\log y_j(t) - \log y_j^*(t)\}$$

where g_j denotes the per capita income growth rate, a is the steady-state growth rate, $y_j(t)$ is the country j’s per capita income, and $y_j^*(t)$ is the output at the steady state where the effective capital–labor ratio stays constant. The growth convergence implies $b<0$. The growth rate can be decomposed into the steady-state growth rate, a, and the catch-up factor, which is the second term. The more the current per capita income level is below the steady-state level, the higher the growth rate becomes. This is what allows economy j to converge to the steady state.

The steady-state income level is changing over time, since even at the steady state the growth rate is positive. Once per capita income reaches the steady state, y^*, then the second term becomes zero and per capita income increases at the constant rate of a.

The steady state for economy j may not be known in reality, unless the economy reaches that stage of constant growth. However, among the advanced economies, it is expected that the steady state (or the goal of the catch-up process) is the income level and growth rate in the US. Advanced economies should converge to the US (or Organisation for Economic Co-operation and Development) level of income. If this holds true, we can substitute the US income level at time t, $y_{US}(t)$, for $y_j^*(t)$:

$$g_j(t) = a + b\{\log y_j(t) - \log y_{us}(t)\}$$

This is the basic regression equation of growth convergence. The growth convergence predicts $b < 0$. In empirical research, the convergence hypothesis can be shown as the negative correlation between the period average of the per capita GDP growth rate and per capita GDP at the beginning of the period. As stated above, low-income economies can grow faster than high-income economies. There may be several reasons for this. First, the high marginal productivity of capital in low-income economies implies a higher growth rate. This is possible even if the production function has the same specification. Second, it is more likely that a low-income economy has a lower level of technology, which depresses the income level. However, it is possible to achieve a higher growth rate through technology transfers and learning-by-doing. For a low-income economy, imitation, not innovation, may be enough to increase total factor productivity. Third, starting from low levels of infrastructure and human capital, public spending on these public goods and education can easily increase productivity. In the conditional convergence literature, conditions are often fixed at the initial point (the year in which the analysis starts) so that growth can be tracked in subsequent decades.

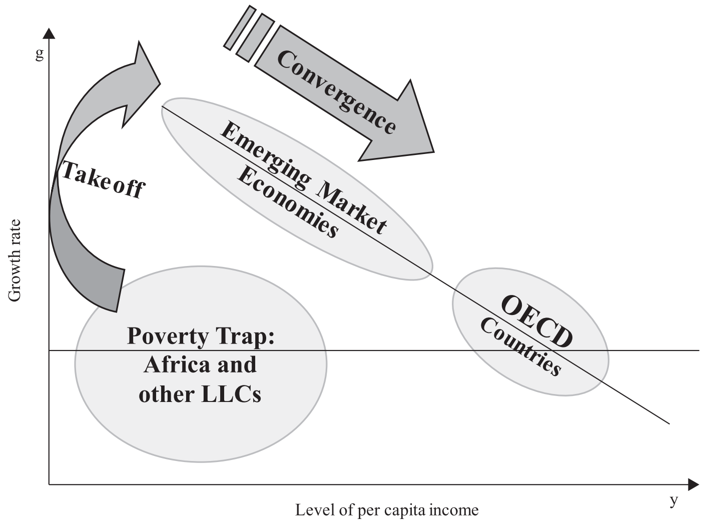
Of course, not all low-income economies can achieve high rates of growth. There are many economies that are stuck in a low-income, low-growth state. Many factors can explain the poverty trap. For example, much of the population may be living at a minimum subsistence level so that they have to spend all of their time farming, fishing, or hunting rather than increasing human capital (e.g., education) or improving productivity (e.g., machines). Hence, poverty begets poverty. Under these conditions, a large population was once considered to be a disadvantage (Myrdal 1968). Having exportable resources helps in theory, but often public sector corruption has led to the skimming of export revenues for personal benefits.

Many East Asian economies, which typically lack significant natural resources, have successfully escaped the poverty trap. Scholars and policy makers in East Asian economies tend to credit industrial policies for the takeoff. Under such policies, the government directs resources and credit to industries with the best chances to become competitive in global markets. Private sector companies compete in productivity and those who succeed in exports are rewarded by the government with more resources and financial incentives. The typical East Asian government has also spent substantial amounts on physical infrastructure networks (e.g., roads, electricity, rail, and ports) and the nationwide education system. The positive view of market-friendly interventions by benevolent governments is still prevalent in East Asia. The Asian Miracle, as portrayed by the World Bank (1993), is applicable to the experiences of Japan, the four tigers, and ASEAN-5.

The typical growth convergence pattern is depicted in Figure 5. Once a takeoff from the poverty trap has occurred, often resulting from a big push by the government or significant policy reforms, the economy reaches the growth convergence line and enjoys a virtuous circle of higher growth and more investment as the income level of the population increases.

Although this view is strongly supported by time series data for economies in East Asia, any casual test or rigorous extension to other regions—such as South Asia, Latin America, and Africa—tends to fail. Cross-section and panel data analyses involving all economies in the world for which data are available fail to produce

Figure 5. **Growth Convergence**



Source: Author's illustration.

a downward-sloping convergence line (see, for example, Barro 1991). Hence, East Asia is considered the exception rather than a standard role model.

A single convergence line used in an attempt to explain many economies needs a strong assumption that the specification of the production function is identical across economies and that the only difference is the degree of capital accumulation. In reality, the technological level, whether it is embodied in labor or capital, may be vastly different across economies. Technological progress, often measured through total factor productivity, also differs, as well as the respective shares of capital and labor.

Many factors that are relevant to the production function in each economy can explain differences in growth. The list ranges from historical and geographic conditions to institutions and accumulated human capital. Historical conditions can also include human capital (Barro 1991; Mankiw, Romer, and Weil 1992) and an economy's "colonial origin" (Acemoglu, Johnson, and Robinson 2001, 2002). Demography also matters since the population's age composition, in addition to its overall size, is important for labor inputs (Bloom, Canning, and Malaney 2000). Thus, it becomes standard to consider "conditional convergence," in which the rate of convergence differs among different economies. Hence, convergence paths may not be unique, but rather multiple paths might exist. Theoretically, this reflects differences in the level of technology and its growth contribution (see, for example, Han and Wei 2015).

FDI has played an important role in East Asia's development, with the conspicuous exceptions of Japan and the Republic of Korea. FDI brings in both physical capital and technology associated with the use of capital. Borensztein, De Gregorio, and Lee (1998) showed that FDI contributes more to growth than domestic investment, presumably due to technology transfers; but this only holds when the host economy has sufficient absorptive capacity through accumulated human capital. This appears to be the case in East Asia where educational attainment is relatively high.

B. Stylized Facts of Growth Convergence in Asia

In the rest of this section, I will present the growth convergence pattern in East Asia and propose a framework that encompasses notions of the poverty trap, the middle-income trap, and conditional convergence.[4] Three periods—pre-AFC (1985–1996), intercrises (1999–2007), and post-GFC (2010–2015)—are used as in previous sections. The crisis years (1997–1998 and 2008–2009) are omitted to avoid having average growth rates altered by these two unusual crises. The following discussion uses the period average per capita growth rates as the vertical axis and the log of per capita income (US dollars converted at market exchange rates) of the first year of each period as the horizontal axis. The sample economies are Japan, the four tigers, the ASEAN-5, the four low-income members of ASEAN, the PRC, and India.[5] Recall that the period average growth rates are shown in Table 1.

For the growth convergence figures, the growth rate is taken as a vertical axis, and the income level is taken as a horizontal axis. The convergence hypothesis implies that plots of different periods of a particular economy move along the line from the northwest to the southeast. If several economies can be plotted on the same line, then those economies are expected to converge in the same growth model (technology) toward a high-income, low-growth steady state, which is the goal of development.

As a first attempt, Figure 6 includes all of the aforementioned East Asian economies and India in one graph. The connected dots for each economy are mostly downward sloping, suggesting that growth convergence is evident in the time series data of each economy. Some low-income economies show an upward-sloping line. These upward movements, which depict an acceleration of growth as the income level rises, may actually be part of the takeoff from a poverty trap that resulted from a previously dysfunctional government implementing major reforms.

However, Figure 6 is not appropriate when the global leader, the US, is also moving toward the right on the convergence graph. To be precise, growth convergence should be interpreted as a convergence to the US income level and its steady-state growth rate of about 2% per year.

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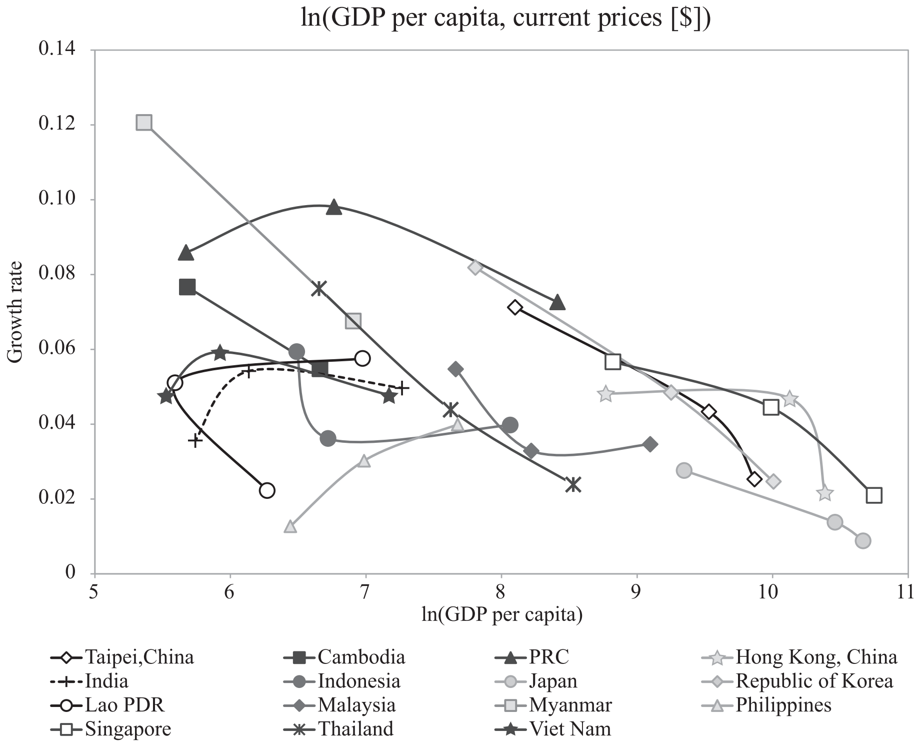
[4]The term middle-income trap was first proposed by Gill and Kharas (2007).

[5]The four low-income ASEAN member economies are Cambodia, the Lao PDR, Myanmar, and Viet Nam.

Figure 6. **Growth Convergence in East Asia**



GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.
Source: Author's calculations.

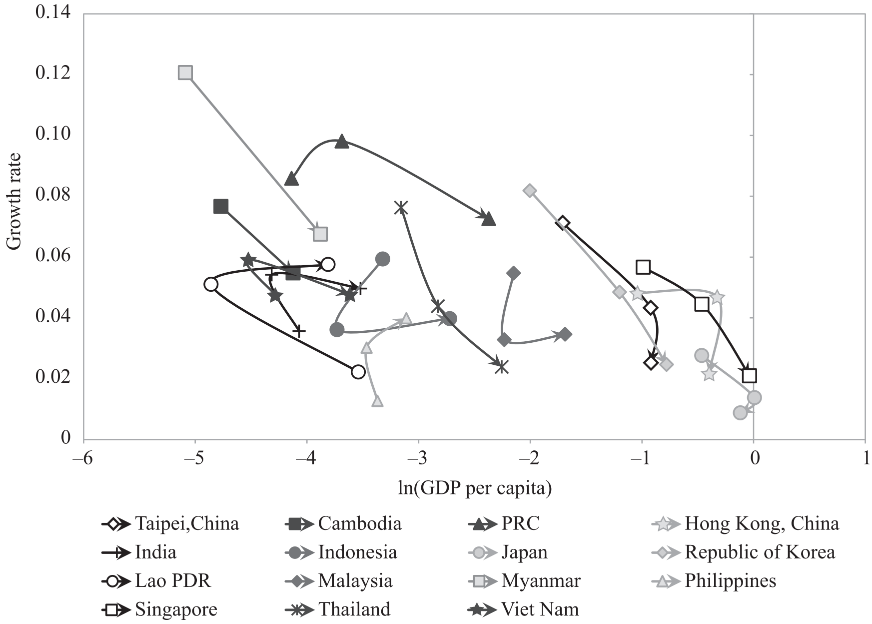
In order to take this into account, the horizontal axis of Figure 7 is modified to be the log difference of an economy's per capita income level to the log of the US per capita income level. The zero in the horizontal axis implies reaching the US per capita income level. Figure 7 shows relative convergence to the US, using the log difference to the US for the horizontal axis. It shows the general tendency of growth convergence for each economy. However, as Figure 7 includes panel data, no single convergence path can be drawn.

C. Multiple Convergence Paths

Figure 7 shows that three distinct groups of economies can be grouped together to share a common convergence path. Group 1 is the high-income group comprising Japan and the four tigers. Group 2 is the middle-income group comprising the PRC, Indonesia, Malaysia, Thailand, and the post-GFC Philippines. Group 3 is the low-income group comprising Cambodia, the Lao PDR, Myanmar, and Viet Nam, as well as India and the pre-AFC and intercrises Philippines.

Figure 7. **Growth Convergence in East Asia: Relative to the US**

ln(GDP per capita, current prices / US GDP per capita, current prices)



GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China, US = United States.
Source: Author's calculations.

Japan and the four tigers clearly belong to the same group as the plots for each of these economies line up on a straight convergence line with little deviation. The PRC seems to have moved from the low-income group to the middle-income group and is approaching the high-income group.

Both Indonesia and the Philippines are on the border area between Groups 2 and 3, while exhibiting atypical time series behavior in that they are not downward sloping. Indonesia has a lower growth rate and per capita income level during the intercrises period than in either the pre-AFC or post-GFC periods, reflecting lasting damage from the AFC that included a significant income decline and the depreciation of the rupiah. Intercrises Indonesia is close to being in the low-income group, while during the pre-AFC and post-GFC periods, it is closer to being in the middle-income group.

The Philippines' time series data show upward movement; its growth accelerated as the income level rose, which is the opposite of what growth convergence predicts. This unusual behavior may be due to long-term improvements in socioeconomic and political conditions over a 30-year period. Political stability and better governance after the AFC and, in particular, after the GFC are often credited with improving the investment climate in the Philippines.

I will now examine the following cases:

Case 1. Indonesia is in the middle-income group and the Philippines is in the low-income group.

Case 2. Both Indonesia and the Philippines are in the low-income group.

Case 3. Indonesia in the intercrises period is in the low-income group and in the other two periods is in the middle-income group. The Philippines in the pre-AFC and the intercrises periods is in the low-income group and in the post-AFC period is in the middle-income group.

For each case, regression analysis is conducted to find the convergence line with the following specification which is consistent with

$$g_j(t) = a + b\{\log y_j(t) - \log y_{us}(t)\}$$

where $t = 1$ (pre-AFC), 2 (intercrises), or 3 (post-GFC); j denotes economy j; and $b < 0$ is expected. The cross-section, time series pooled regression is conducted. Then the growth convergence line for each group of economies is found through estimates of a and b.

Table 2 shows the regression results for all three Indonesia–Philippines cases mentioned above. Using the estimated values of a and b, growth convergence lines can be superimposed on Figure 7.

Figure 8 shows the fitted lines of the regressions for Case 1. The convergence line for Group 1 seems to have only small deviations (errors). However, both Groups 2 and 3 have wide variations around them.

Similarly, Figures 9 and 10 show the growth convergence lines for Cases 2 and 3, respectively, since it is an open question as to whether or not Indonesia and the Philippines should be included in the middle-income group. With all three cases presented, it serves as a robustness test regarding the grouping of economies.

All three figures show downward-sloping convergence lines. Convergence lines are almost parallel in Case 3. In all cases, the middle-income convergence reaches the steady-state growth rate, g, of 2%, but does not reach the level of the high-income steady state. Hence, it is not a matter of fast or slow convergence with the high-income steady state, but the middle-income trap does exist. To avoid it, economies on the middle-income convergence line have to eventually make the jump to the high-income convergence line.

The three convergence lines suggest that if an economy fails to jump from one convergence path to a higher one, then the economy will end up in a state in which the gap with the US income level cannot be narrowed.

D. Conditional Convergence with Jumps

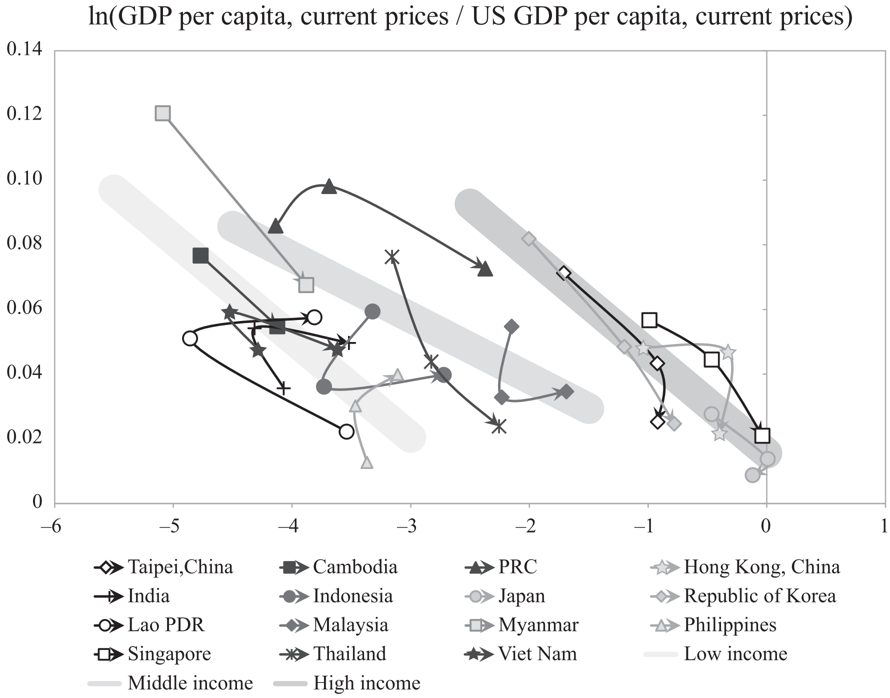
Figure 11 explains in a schematic way how jumps are required to avoid a trap: one type of jump is from a low-income convergence path to a middle-income one,

Table 2. **Conditional Convergence**

		Case 1			Case 2			Case 3		
		α	β		α	β		α	β	
Group 1	Coefficient	0.016	−0.031	Coefficient	0.016	−0.031	Coefficient	0.016	−0.031	**Case 1:** Hong Kong, China; Japan; Republic of Korea; Singapore; and Taipei,China
	STD Er	0.005	0.005	STD Er	0.005	0.005	STD Er	0.005	0.005	
	t-stat	3.298	−6.172	t-stat	3.298	−6.172	t-stat	3.298	−6.172	**Case 2:** Hong Kong, China; Japan; Republic of Korea; Singapore; and Taipei,China
	p stat	0.006	0.000	p stat	0.006	0.000	p stat	0.006	0.000	
	R-bar sq	0.726		R-bar sq	0.726		R-bar sq	0.726		**Case 3:** Hong Kong, China; Japan; Republic of Korea; Singapore; and Taipei,China
	# obs	15		# obs	15		# obs	15		
		α	β		α	β		α	β	
Group 2	Coefficient	0.001	−0.019	Coefficient	−0.013	−0.026	Coefficient	−0.011	−0.024	**Case 1:** PRC, Indonesia, Malaysia, and Thailand
	STD Er	0.023	0.008	STD Er	0.021	0.007	STD Er	0.021	0.007	**Case 2:** PRC, Indonesia, Malaysia, and Thailand
	t-stat	0.050	−2.359	t-stat	−0.629	−3.517	t-stat	−0.518	−3.212	**Case 3:** PRC; Malaysia; and Thailand; Indonesia ($t = 1, 3$); Philippines ($t = 3$)
	p stat	0.961	0.040	p stat	0.549	0.010	p stat	0.616	0.009	
	R-bar sq	0.293		R-bar sq	0.587		R-bar sq	0.459		
	# obs	12		# obs	9		# obs	12		
		α	β		α	β		α	β	
Group 3	Coefficient	−0.071	−0.031	Coefficient	−0.042	−0.024	Coefficient	−0.089	−0.035	**Case 1:** Cambodia, India, Lao PDR, Myanmar, Philippines, Viet Nam
	STD Er	0.031	0.008	STD Er	0.027	0.007	STD Er	0.033	0.008	
	t-stat	−2.282	−3.973	t-stat	−1.584	−3.537	t-stat	−2.711	−4.309	**Case 2:** Cambodia, India, Indonesia, Lao PDR, Myanmar, Philippines, Viet Nam
	p stat	0.039	0.001	p stat	0.132	0.003	p stat	0.017	0.001	
	R-bar sq	0.496		R-bar sq	0.39		R-bar sq	0.539		**Case 3:** Cambodia; India; Indonesia ($t = 2$); Lao PDR; Myanmar; Philippines ($t = 1, 2$); Viet Nam
	# obs	16		# obs	19		# obs	16		

Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.
Source: Author's calculations.

Figure 8. **Three Groupings of Economies—Case 1**



GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China, US = United States.
Source: Author's calculations.

and the other jump is from a middle-income convergence path to a higher-income one.

A group of economies belongs to the same convergence line. For example, Japan and the four tigers belong to one convergence line, while middle-income ASEAN economies share another line. The low-income ASEAN economies also have a common convergence path. This means that economies that belong to the same convergence path have a similar level of technology. The difference among them is the degree of capital accumulation.

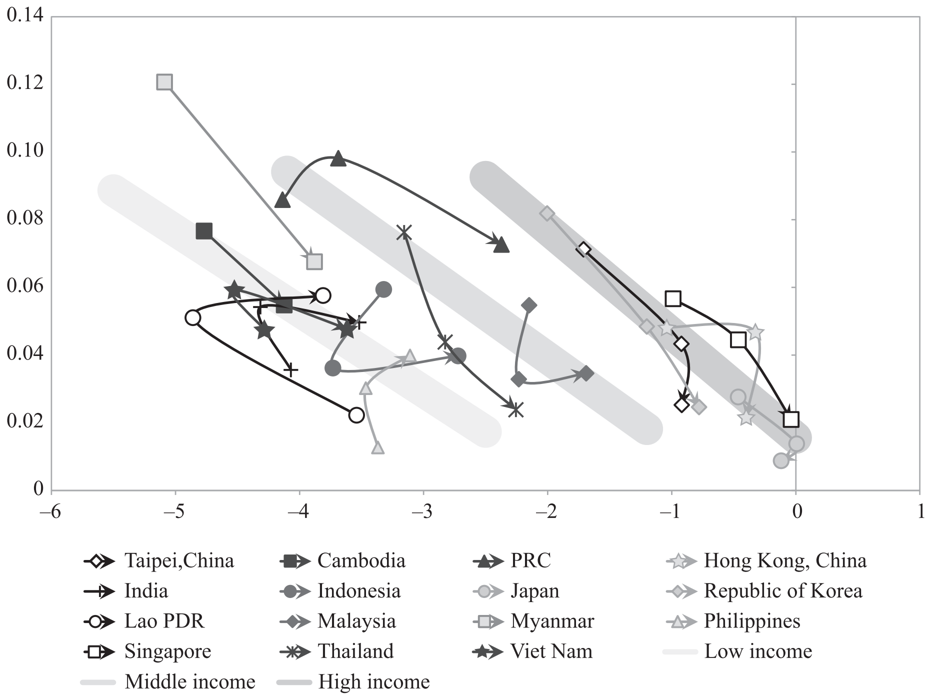
The PRC maintains a relatively high growth rate although its per capita income level is approaching the top of the middle-income range. Although the PRC's growth rate is declining slightly, it still seems possible for it to avoid the middle-income trap.

E. Middle-Income Trap in the Context of Growth Convergence

Within the framework proposed above, the middle-income trap is understood as a result of failing to make the jump from the middle-income convergence path to

Figure 9. **Three Groupings of Economies—Case 2**

ln(GDP per capita, current prices / US GDP per capita, current prices)

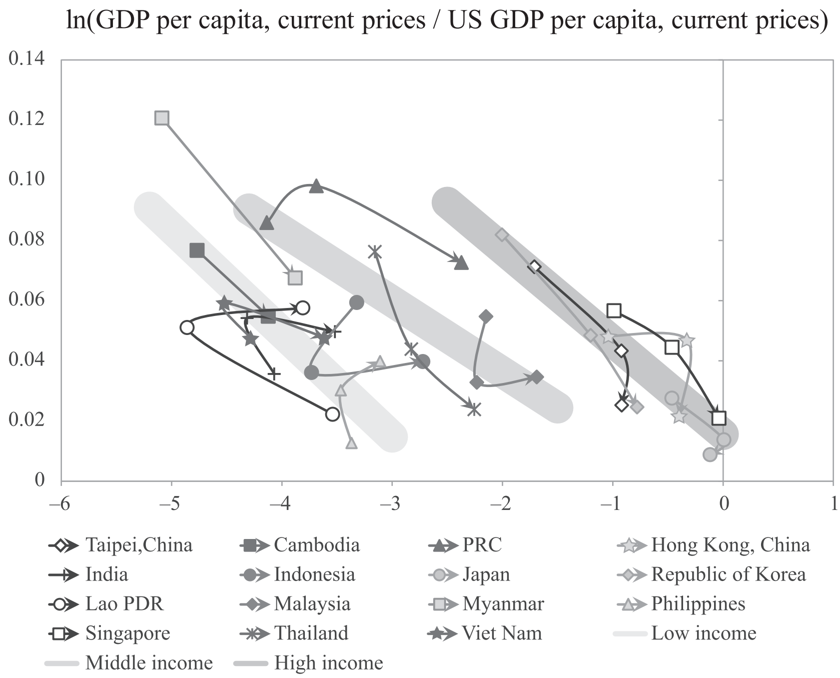


GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China, US = United States.
Source: Author's calculations.

the high-income convergence path. Hence, growth convergence results in a steady state that is lower than the steady state of the advanced economies (or the US). When an economy's growth rate is equal to the long-run per capita growth rate of the US, the gap with the US in terms of per capita income (position on the horizontal axis) stays constant. When an economy follows the middle-income convergence path to the steady state, the income gap remains permanently and the economy is said to be stuck in the middle-income trap. In fact, it is not a trap, but rather a failure to adopt innovation and progress in the use of technology. For example, while Thailand is approaching an average per capita growth rate of 2%, it may fail to catch up to the per capita income level of the US unless it makes a shift toward innovation.

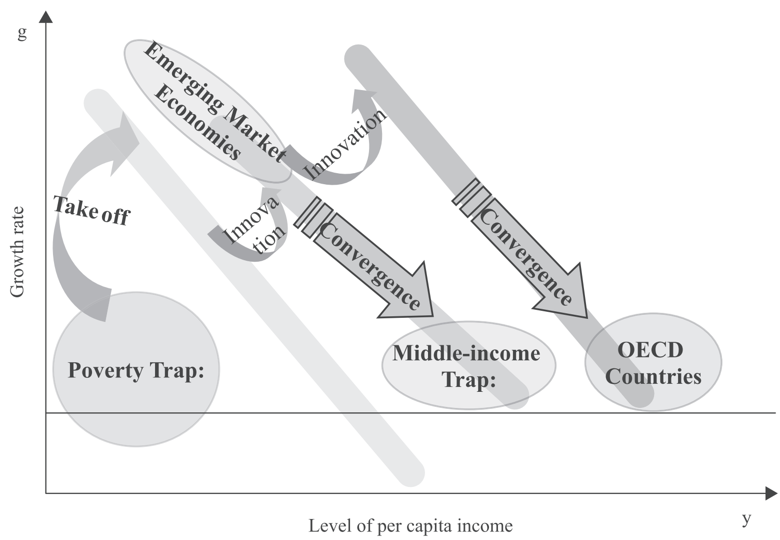
Aiyar et al. (2013) conducted an investigation very similar to this study in which they compared time series data for Asian and Latin American emerging market economies and defined the middle-income trap as a sudden deceleration in growth. By using probit regressions, they argue that "(i) middle-income economies are, in fact, disproportionately likely to experience growth slowdowns, and (ii) this

Figure 10. **Three Groupings of Economies—Case 3**



GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China, US = United States.
Source: Author's calculations.

Figure 11. **Punctuated Conditional**



OECD = Organisation for Economic Co-operation and Development.
Source: Author's illustration.

result is robust to a wide range of income thresholds for defining ‘middle income’ ” (Aiyar et al. 2013, 12). Then, they go on to examine factors that cause sudden growth slowdowns. The difference between my approach and that of Aiyar et al. (2013) is the assumption here that multiple growth convergence lines exist so that the middle-income steady state can be arrived at through a gradual slowdown, which is in contrast to the idea that a middle-income economy can fall off from the growth convergence line.

Felipe, Kumar, and Galope (2014) also examined economies’ transitions across income groups. They searched for evidence that supports the existence of the middle-income trap; that is, an economy that is stuck in middle-income status. They refuted this proposition in favor of a hypothesis that there can be a slow, rather than a fast, transition from middle- to high-income status. Im and Rosenblatt (2013) examined transition phases in the cross-economy distribution of income. Their transition matrix analysis provides little support for the idea of a middle-income trap. Han and Wei (2015) also conducted transition matrix analysis and rejected the existence of an unconditional middle-income trap. They argued that there are factors—such as working-age population, financial development, and macroeconomic stability—that differentiate fast- and slow-growing economies.

Eichengreen, Park, and Shin (2012, 2013) argued that there are certain income levels at which a sudden slowdown tends to occur: \$10,000–\$11,000 and \$15,000–\$16,000 (in 2005 dollars and in purchasing power parity terms). It is not clear whether they argue that this slowdown is a natural process of middle-income growth convergence or the result of falling off from the high-income growth convergence path. However, their conclusion is that “slowdowns are less likely in countries where the population has a relatively high level of secondary and tertiary education and where high-technology products account for a relatively large share of exports” (Eichengreen, Park, and Shin 2013; i). Meanwhile, this paper’s finding is that an economy needs innovation to jump from the middle-income convergence path to a high-income convergence path.

Bulman, Eden, and Nguyen (2014) argue that the determinants of growth at low-income levels are different from those at high-income levels. Their model implies that the transition from low- to high-income status can be smooth if an economy redirects its resources to factors that are important for high-income growth. The implication is that a middle-income trap does not exist.

Robertson and Ye (2013), in contrast to the above papers, confirmed the existence of a middle-income trap, which is the state in which an economy’s per capita income will not rise beyond the middle-income range over an infinite period of time into the future. They tested their hypothesis with the Augmented Dickey–Fuller unit root test, which was not immediately conclusive because this test requires a large sample and the sample size for growth convergence and the middle-income trap is limited.

V. Concluding Remarks

This paper has taken a novel approach by defining the middle-income trap in the context of growth convergence. An empirical investigation using panel data was also an innovation. However, the results are more in the form of suggestive evidence rather than hypothesis testing due to the limited sample size.

With the proper grouping of economies, the estimations in this paper show that each of the selected Asian economies is following one of the three convergence paths. The findings suggest that the middle-income trap can be viewed as a middle-income economy that fails to make a jump and converge toward a high-income steady state. Furthermore, making this jump requires significant reforms and/or a policy shift to stimulate enough innovation needed for technological progress.

Admittedly, the empirical results are subject to further examination. In addition, extending the analysis to other regions is left for future research.

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*ADB recognizes "China" as the People's Republic of China.

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Appendix. Growth Convergence

The following derivation of the convergence regression is taken from chapters 2 and 3 of Acemoglu (2009) with a few modifications and an additional complexity with heterogeneous economies.

Consider a labor-augmenting, slow-growth model with a constant savings rate, s, and a constant depreciation rate, z:

$$Y(t) = F\left(K(t), A(t)L(t)\right) \tag{1}$$

where Y is output, F is a production function of homogeneous of degree one, K is capital, A is the technology level, and L is labor. The effective capital–worker ratio and effective output–labor ratio are defined as

$$k(t) = \frac{K(t)}{A(t)L(t)}$$

With homogeneous of degree one, equation (1) can be transformed as

$$\begin{aligned}\frac{Y(t)}{A(t)L(t)} &= F\left(\frac{K(t)}{A(t)L(t)}, 1\right)\\ &= f\left(k(t)\right) \end{aligned} \tag{2}$$

Per capita income is defined as

$$y(t) = \frac{Y(t)}{L(t)}$$

Then, using this definition of $y(t)$ and (2) becomes

$$y(t) = A(t) f(k(t)) \tag{3}$$

A change in $K(t)$, $dK(t)$, is a new accumulation of capital by investment, which is assumed to be equal to savings minus depreciation.

$$dK(t) = sY(t) - zK(t)$$

where d is the notation of time derivative (assuming a continuous time model). The growth rate of k can be defined as

$$\frac{dk}{k} = \frac{dK}{K} - \frac{dA}{A} - \frac{dL}{L} \tag{4}$$

where time notation (t) is omitted. Assuming a constant rate of technological progress, a, and a constant rate of labor growth, n, results in

$$\frac{dk}{k} = \frac{dK}{K} - a - n \tag{5}$$

Combining (4) and (5) results in

$$\begin{aligned}\frac{dk}{k} &= \frac{sY(t) - zK(t)}{K(t)} - a - n \\ &= \frac{sY(t)}{K(t)} - (z + a + n)\end{aligned}$$

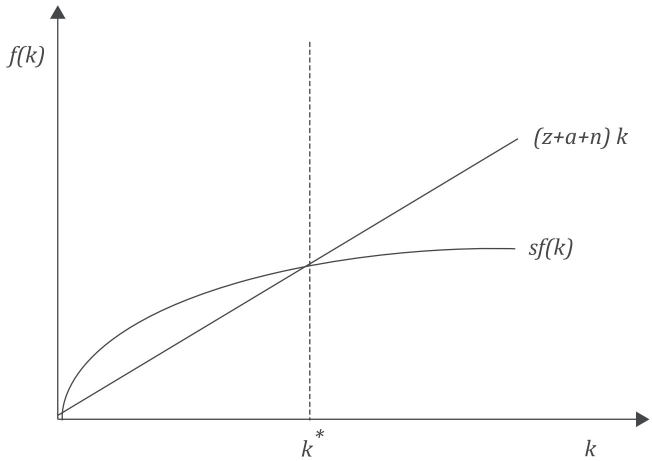
Substituting $Y(t) = A(t)L(t)f(k(t))$, which can be rearranged from (2), results in

$$\frac{dk(t)}{k(t)} = \frac{sf(k(t))}{k(t)} - (z + a + n) \tag{6}$$

or equivalently,

$$dk(t) = sf(k(t)) - (z + a + n)k(t) \tag{7}$$

Figure A.1. **Definition of the Steady State**



Source: Author's illustration.

When the production function F satisfies certain conditions (Assumptions 1 and 2 in Acemoglu 2009), there exists a unique, globally stable steady state $k^* > 0$, where

k^* is k such that $sf\,(k^*) - (z + a + n)\,k^* = 0$

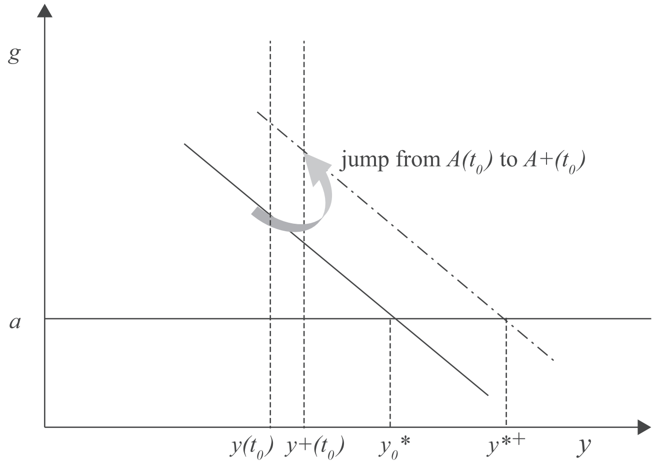
The steady-state per capita income is denoted as y^* and $y^*(t) = A(t)f(k^*)$.

At the steady state, Y/L and K/L increases at the rate of a, which is the rate of technological progress. Ultimately, the economy will converge to a state where the growth rate equals the technological progress rate. It is easy to show in comparative static exercises that k^* is an increasing function of s and $A(0)$; that is, the initial level of technology and decreasing function of n and z. Figure A.1 depicts how to find k^* from equation (7) and a given set of parameters.

Recalling equation (3) and differentiating with respect to time, the growth rate, g, of per capita income can be shown as

$$\begin{aligned} g &= \frac{dy(t)}{y(t)} \\ &= \frac{dA(t)}{A(t)} + \frac{f'\,(k(t))\,dk(t)}{f\,(k(t))} \\ &= a + \left(\frac{f'\,(k(t))\,k(t)}{f\,(k(t))}\right)\left(\frac{dk(t)}{k(t)}\right) \\ &= a + \varepsilon\,(k)\,\frac{dk(t)}{k(t)} \end{aligned} \tag{8}$$

Figure A.2. **Shift in the Convergence Path**



Source: Authors' illustration.

where $\varepsilon(k) \equiv f'(k(t))\, k(t)/f(k(t))$ is the elasticity of the production function. Note that $0 < \varepsilon(k) < 1$ and $\{dk(t)/k(t)\}$ was shown in equation (6).

Acemoglu (2009, 80–81) describes the process of taking the first-order Taylor expansion of equation (6) with respect to log $k(t)$ and substituting it into equation (8). Then, it becomes the following convergence equation (Acemoglu 2009, 81):

$$g = \frac{dy(t)}{y(t)} \approx a - \varepsilon\,(k^*)\,(1 - \varepsilon\,(k^*))\,(z + a + n)\,(\log k(t) - \log k^*)$$

$$g = \frac{dy(t)}{y(t)} \approx a - (1 - \varepsilon\,(k^*))\,(z + a + n)\,(\log k(t) - \log k^*) \tag{9}$$

The first term is the steady-state growth rate, which is the technological progress rate. The second term is the convergence term. If $y < y^*$ then $g > a$, and vice versa. This shows that the growth rate is a decreasing function of y, thus the downward-sloping convergence line. This is depicted as the solid line in Figure A.2.

The following is an application of the above summary of the theory of convergence of Acemoglu (2009), which is needed to derive multiple convergence lines. Suppose that at some point of time, $t = t_0$, there was jump in technology from $A(t_0)$ to $A^+(t_0)$, other parameters being equal, where

$$A\,(t_0) < A^+\,(t_0)$$

Then, k^* and y^* will become larger and the convergence line shifts to the right as depicted in the broken line in Figure A.2. As $k(t)$ is defined as $K(t)/A(t)L(t)$, a sudden jump in the value of A will lower $k(t_0)$. However, $y(t_0) = A(t_0)\, f(k(t_0))$ will become higher, the economy will jump from $(y(t_0), g(t_0))$ to $(y^+(t_0), g^+(t_0))$ to $y^+(t_0)$, and the growth rate will become higher due to the convergence term. These lines correspond to the multiple convergence lines in the text.

The Impact of the Minimum Wage on Male and Female Employment and Earnings in India

NIDHIYA MENON AND YANA VAN DER MEULEN RODGERS*

This study examines how employment and wages for men and women respond to changes in the minimum wage in India, a country known for its extensive system of minimum wage regulations across states and industries. Using repeated cross sections of India's National Sample Survey Organization employment survey data for the period 1983–2008 merged with a newly created database of minimum wage rates, we find that, regardless of gender, minimum wages in urban areas have little to no impact on labor market outcomes. However, minimum wage rates increase earnings in the rural sector, especially for men, without any employment losses. Minimum wage rates also increase the residual gender wage gap, which may be explained by weaker compliance among firms that hire female workers.

Keywords: employment, gender, India, minimum wage, wages
JEL codes: J52, J31, K31, O12, O14

I. Introduction

The minimum wage is primarily used as a vehicle for lifting the incomes of poor workers, but it can also entail distortionary costs. In a perfectly competitive labor market, an increase in a binding minimum wage causes an unambiguous decline in the demand for labor. Jobs become relatively scarce, some workers who would ordinarily work at a lower market wage are displaced, and other workers see an increase in their wages. Distortionary costs from minimum wages are potentially more severe in developing economies given their large informal sectors. A minimum wage primarily protects workers in the urban formal sector whose earnings already exceed the earnings of workers in the rural and informal sectors by a wide margin. Employment losses in the regulated formal sector translate into more workers seeking jobs in the unregulated informal sector. This shift may result in lower, not higher, wages for poor workers who are engaged predominantly in the informal

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sector. Even a small increase in the minimum wage can have sizable disemployment effects in developing economies if the legal wage floor is high relative to prevailing wage rates and a large proportion of workers earn the legislated minimum.

To the extent that female workers are relatively concentrated in the informal sector and men in the formal sector, fewer women stand to gain from binding minimum wages in the formal sector. Further, if minimum wages discourage formal sector employment, a disproportionate number of women can experience decreased access to formal sector jobs. For women who remain employed in the formal sector, the minimum wage can help to raise their relative average earnings. Because the female earnings distribution falls to the left of the male earnings distribution in most economies, a policy that raises the legal minimum wage irrespective of gender, if properly enforced, should help to close the male–female earnings gap (Blau and Kahn 1995). Although the gender wage gap in the formal sector shrinks, the wage gain for women can come at the expense of job losses for low-wage female workers. Hence, disemployment effects may be larger for women than men in the formal sector.

Critics of the minimum wage state that employment losses from minimum-wage-induced increases in production costs are substantial.[1] Advocates, however, argue that employment losses are small and any reallocation of resources that occurs will result in a welfare-improving outcome through the reduction of poverty and an improvement in productivity. Our study contributes to this debate by analyzing the relationship between the minimum wage and employment and earnings outcomes for men and women in India.

India constitutes an interesting case given its history of restrictive labor market policies that have been blamed for lower output, productivity, investment, and employment (Besley and Burgess 2004). As a federal constitutional republic, India's labor market exhibits substantial variation across its 28 geographical states in terms of the regulatory environment. Labor regulations have historically fallen under the purview of states, a framework that has allowed state governments to enact their own legislation, which includes minimum wage rates that vary by age (child workers, adolescents, and adults); skill level; and detailed job categories.[2] Each state sets minimum wage rates for particular occupational categories regardless of whether the jobs are in the formal or informal sector, with the end result that there are more than 1,000 different minimum wage rates across India in any given year. This wide degree of variation and complexity may have hindered compliance relative to a simpler system with a single wage set at the national or state level (Rani et al. 2013, Belser and Rani 2011).

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[1] This debate is carefully reviewed in Card and Krueger (1995); Belman and Wolfson (2014); and Neumark, Salas, and Wascher (2014).

[2] Importantly, there is no distinction in pay by gender. However, given the complexity of enforcement arising from the myriad wage levels, female workers and those in rural areas tend to be paid less than the legal wage.

To examine how the minimum wage affects men and women's employment and wages in India, this study uses six waves of household survey data from the National Sample Survey Office (NSSO) spanning the 1983–2008 period, merged with an extensive and unique database on minimum wage rates over time and across states and industries. Also merged into the NSSO data are separate databases of macroeconomic and regulatory variables at the state level that capture underlying market trends. A priori, we expect that India's minimum wage increases would bring relatively fewer positive effects for women than men, particularly if women have less bargaining power and face greater obstacles to being hired in the labor market. Our empirical results confirm these expectations in the case of women's relative wages, but we find little evidence of disemployment effects either for them or for men.

II. Literature Review

A. Employment and Wage Effects

The past quarter of a century has seen a surge in scholarly interest in the impact of minimum wage legislation on labor market outcomes across economies, with much of that research focusing on changes in employment. Results have varied across studies, with some reporting statistically significant and large negative employment effects at one end of the spectrum and others finding small positive effects on the other. In an effort to synthesize this large body of work, Belman and Wolfson (2014) conducted a meta-analysis for a large number of studies of industrialized economies and concluded that minimum wage increases may lead to a very small disemployment effect: raising the minimum wage by 10% causes employment to fall by between 0.03% and 0.6%.

For developing and transition economies, the estimated employment effects also tend to be negative, but with more variation compared to industrialized economies.[3] Disemployment effects have been found for Bangladesh (Anderson, Hossain, and Sahota 1991); Brazil (Neumark, Cunningham, and Siga 2006); Colombia (Bell 1997, Maloney and Mendez 2004); Costa Rica (Gindling and Terrell 2007); Hungary (Kertesi and Köllo 2003); Indonesia (Rama 2001, Suryahadi et al. 2003); Nicaragua (Alaniz, Gindling, and Terrell 2011); Peru (Baanante 2004); and Trinidad and Tobago (Strobl and Walsh 2003). But not all estimates are negative. There has been no discernable impact on employment in Mexico (Bell 1997) and Brazil (Lemos 2009). In the People's Republic of China (PRC), the minimum wage

[3]For details, see two recently published meta-analyses for developing economies, Betcherman 2015 and Nataraj et al. 2014. This section expands on the findings in these studies by focusing more on the gender-disaggregated impacts of the minimum wage.

appears to have had a negative impact only in the eastern region of the country, while it has had either no impact or a slightly positive impact elsewhere (Ni, Wang, and Yao 2011; Fang and Lin 2013). Negligible or even small positive employment effects have been found in other cases when national-level estimates are disaggregated, such as in the case of workers in Indonesia's large firms (Rama 2001; Alatas and Cameron 2008; Del Carpio, Nguyen, and Wang 2012).

Minimum wage impacts in developing economies vary considerably not only because of labor market conditions and dynamics, but also because of noncompliance, inappropriate benchmarks, and the presence of large informal sectors.[4] In fact, most of the negative minimum wage impacts across economies are for formal sector employment where there is greater compliance among firms. Noncompliance with minimum wage regulations is directly related to difficulties in enforcement and can take the form of outright evasion, legal exemptions for such categories as part-time and temporary workers, and cost shifting through the avoidance of overtime premiums. Because minimum wages are relatively more costly for small firms in the informal sector, noncompliance is pervasive there.

Compliance costs are higher for smaller firms in the informal sector because they tend to hire more unskilled workers, young workers, and female workers than larger firms in the formal sector. Given that average wages for these demographic groups are low, compliance is costly as the minimum wage is more binding. For example, Rani et al. (2013) found an inverse relationship between compliance and the ratio of the legislated minimum wage to median wages in a sample of 11 developing economies. Among individual economies, Gindling and Terrell (2009) found that minimum wages in Honduras are enforced only in medium- and large-scale firms where increases in the minimum wage lead to modest increases in average wages but sizable declines in employment. There is no impact among small-scale firms or among individuals who are self-employed. Similar evidence for the positive relationship between firm size and compliance was found in Strobl and Walsh (2003) in their study on Trinidad and Tobago.

Not surprisingly, most of these studies have found positive impacts of the minimum wage on formal sector wages, with the strongest impact close to the legislated minimum and declining effects further up the distribution. In a type of "lighthouse effect," wages in the informal sector may also rise if workers and employers see the legislated minimum as a benchmark for their own wage-bargaining and wage-setting practices, respectively (e.g., Maloney and Mendez 2004, Baanante 2004, and Lemos 2009). A number of studies have found that minimum wage increases reduce wage compression since low-wage workers experience the strongest wage boosts from the new legislated minimum (Betcherman 2015).

[4]For details, see Squire and Suthiwart-Narueput (1997), Nataraj et al. (2014), and Betcherman (2015).

B. Gender Differences in Minimum Wage Impacts

While there is a large amount of empirical literature estimating minimum wage impacts on employment and wages, relatively few studies have included a gender dimension in their analysis. Among the exceptions for industrialized economies is Addison and Ozturk (2012), who used a panel data set of 16 Organisation for Economic Co-operation and Development economies and found substantial disemployment effects for women: a 10% increase in the minimum wage causes the employment-to-population ratio to fall by up to 7.3%. Among studies for individual economies, Shannon (1996) found that adverse employment effects from Canada's minimum wage are more severe for women than men, although the gender earnings gap shrank for women who kept their jobs. A similar result is found for Japan in Kambayashi, Kawaguchi, and Yamada (2013), who identified sizable disemployment effects for women and a compression in overall wage inequality. Yet not all employment effects for women are negative. In the United Kingdom, for instance, minimum wages are associated with a 4% increase in employment for women while the estimated employment increase for men is less robust (Dickens, Riley, and Wilkinson 2014). Further, not all gender-focused studies on industrialized economies have found reductions in the gender earnings gap. For instance, Cerejeira et al. (2012) found that an amendment to the minimum wage law in Portugal that applied to young workers increased the gender earnings gap because of the associated restructuring of fringe benefits and overtime payments that favored men.

Among developing economies, evidence for Colombia indicates that minimum wage increases during the 1980s and 1990s caused larger disemployment effects for female heads of households relative to their male counterparts (Arango and Pachón 2004). Larger adverse employment effects for women than men were also found in the PRC for less educated workers (Jia 2014) and in particular regions (Fang and Lin 2013, Wang and Gunderson 2012). The sharp increase in the real minimum wage in Indonesia since 2001 has contributed to relatively larger disemployment effects for women in the formal sector (Suryahadi et al. 2003, Comola and de Mello 2011) and among nonproduction workers (Del Carpio, Nguyen, and Wang 2012). In Mexico, among low-skilled workers, women's employment was found to be quite sensitive to minimum wage changes (with elasticities ranging from –0.6 to –1.3), while men's employment was more insensitive (Feliciano 1998).

Not all studies with a gender dimension have found disemployment effects for women. For instance, Montenegro and Pagés (2003) studied changes in the national minimum wage over time in Chile and found that the demand for male workers fell and the supply of female workers rose, resulting in small net employment gains for women. The explanation for their finding is the existence of imperfect competition in the female labor market that caused women's wages to fall below their marginal product. Further, Muravyev and Oshchepkov (2013) argued that the imposition of minimum wages in the Russian Federation during 2001–2010 resulted in no statistically significant effects on unemployment rates for prime-age workers as a whole or for prime-age working women.

Evidence of the impact of a minimum wage on women's wages and the gender wage gap is mixed essentially because it depends on the extent to which employers comply with the legislation. Greater noncompliance for female workers has been documented for a number of economies across developing regions. Minimum wage legislation in Kenya was found to increase wages for women in nonagricultural activities but not in agriculture, mostly because compliance rates were lower in agricultural occupations (Andalon and Pagés 2009). Also finding mixed results for women's earnings were Hallward-Driemeier, Rijkers, and Waxman (2015), who showed that increases in Indonesia's minimum wage contributed to a smaller gender wage gap among more educated production workers but a larger gap among production workers with the least amount of education. The authors suggest that more educated women have relatively more bargaining power, which induces firms to comply with minimum wage legislation. As another example, the Costa Rican government implemented a comprehensive minimum wage compliance program in 2010 based on greater public awareness of the minimum wage, new methods for employees to report compliance violations, and increased inspections. As a result, the average wage of workers who earned less than the minimum wage before the program rose by about 10%, with the largest wage gains for women, workers with less schooling, and younger workers. Moreover, there was little evidence of a disemployment effect for full-time male and female workers (Gindling, Mossaad, and Trejos 2015).

Looking more broadly at the gendered effects of the minimum wage on measures of well-being, Sabia (2008) found that minimum wage increases in the United States did not help to reduce poverty among single working mothers because the minimum wage was not binding for some and led to disemployment and fewer working hours for others. Among developing economies, Menon and Rodgers (2013) found that restrictive labor market policies in India that favor workers (including the minimum wage) contribute to improved job quality for women for most measures. However, such regulations bring fewer benefits for men. Estimates indicate that for men, higher wages come at the expense of fewer hours, substitution toward in-kind compensation, and less job security.

Looking beyond labor market effects, Del Carpio, Messina, and Sanz de Galdeano (2014) analyzed the impact of province-level minimum wages on employment and household consumption in Thailand and found that exogenously set regional wage floors are associated with small negative employment effects for women, the elderly, and less educated workers, while they are associated with large positive wage gains for working-age men. These wage gains contributed to increases in average household consumption, although such improvements tended to be concentrated around the median of the distribution. Closely related to these findings, Lemos (2006) found that minimum wages in Brazil have had deleterious effects on the poor by raising the prices of the labor-intensive goods that they purchase. These adverse price impacts are strongest in poorer regions of the country.

III. Methodology and Data

Our analysis uses an empirical specification adapted from Neumark, Salas, and Wascher (2014) and Allegretto, Dube, and Reich (2011) that relates employment outcomes to productivity characteristics and minimum wage regulations across space and time. A sample of individual-level, repeated, cross-sectional data from India's NSSO for the period 1983–2008 is used to identify the effects of the minimum wage on employment and earnings outcomes, conditional on state and year variations.

The determinants of employment for an individual are expressed as follows:

$$E_{ijst} = a + \beta_1 MW_{jst} + \beta_2 X_{ijst} + \beta_3 P_{st} + \beta_4 \varnothing_s + \beta_5 T_t + \beta_6 (\varnothing_s * T_t) + \vartheta_{ijst} \quad (1)$$

where i denotes an employee, j denotes an industry, s denotes a state, and t denotes time. The dependent variable E_{ijst} represents whether or not an individual of working age is employed in a job that pays cash wages. The notation MW_{jst} represents minimum wage rates across industries, states, and time. The notation X_{ijst} is a set of individual and household characteristics that influences people's employment decisions. These characteristics include gender, education level attained, years of potential experience and its square, marital status, membership in a disadvantaged group, religion, household headship, rural versus urban residence, and the number of preschool children in the household. Most of these variables are fairly standard control variables in wage regressions across economies. Specific to India, wages tend to be lower for individuals belonging to castes that are perceived as being deprived or disadvantaged; these castes are commonly referred to as the "scheduled" castes or tribes. Wages are also typically lower for individuals whose religion is not Hinduism. The matrix P_{st} represents a set of control variables for a variety of economic indicators at the state level: net real domestic product, the unemployment rate, indicators of minimum wage enforcement, and variables for the labor market regulatory environment.

The $\varnothing_s$ notation is a state-specific effect that is common to all individuals in each state, and T_t is a year dummy that is common to all individuals in each year. The state dummies, the year dummies, and the state-level economic indicators help to control for observed and unobserved local labor market conditions that affect men and women's employment and earnings. In particular, the state and year dummies are important to control for state-level shocks that may be correlated with the timing of minimum wage legislation (Card 1992, Card and Krueger 1995). Equation (1) also allows state effects to vary by time to address the fact that, individually, these controls may be insufficient to capture all of the heterogeneity in the underlying economic conditions (Allegretto, Dube, and Reich 2011). Finally, ϑ_{ijst} is an individual-specific idiosyncratic error term.[5] Equation (1) is estimated separately by gender and by rural and urban status.

Our analysis also considers the impact of the minimum wage on the residual wage gap between men and women. All regressions are weighted using sample weights provided in the NSSO data for the relevant years and standard errors are clustered at the state level. All regressions are separately estimated with real and nominal minimum wage rates. Since the results are similar, the tables only report estimations for the real minimum wage. The movement of workers into and out of states with prolabor or proemployer legislative activity is unlikely to contaminate results since migration rates are low in India (Munshi and Rosenzweig 2009, Klasen and Pieters 2015).

We use six cross sections of household survey data collected by the NSSO. As shown in Table A.1, the data include the years 1983 (38th round), 1987–1988 (43rd round), 1993–1994 (50th round), 1999–2000 (55th round), 2004–2005 (60th round), and 2007–2008 (64th round). We utilize the Employment and Unemployment Module—Household Schedule 10 for each round. These surveys have detailed information on employment status, wages, and a host of individual and household characteristics.

To construct the full sample for the employment regressions, we appended each cross section across years and retained all individuals of prime working age (15–65 years old) in agriculture, services, and manufacturing with measured values for all indicators. The pooled full sample has 3,332,094 observations. To construct the sample for the wage regressions, we restricted the full sample to all individuals with positive daily cash wages. The pooled wage sample has 597,621 observations. One of the steps in preparing the data entailed reconciling changes over time in NSSO state codes that arose, in part, from the creation of new states in India (e.g., the creation of Jharkhand from southern Bihar in 2000). Newly created states were combined with the original states from which they were created in order to maintain a consistent set of state codes across years. In addition, Union Territories were combined with the states to which they are located closest in geographic terms.

Sample statistics for the pooled full sample in Table 1 indicate that a fairly low percentage of individuals were employed for cash wages during the period, with men experiencing a sizable advantage relative to women in both 1983 and 2008. The table further shows considerable gender differences in educational attainment. In 1983, 42% of men were illiterate compared with 74% of women, while 15% of men and 6% of women had at least a secondary school education. These percentages changed

[5]We follow equation (1) to be consistent with Neumark, Salas, and Wascher (2014) and Allegretto, Dube, and Reich (2011). This equation is an incomplete version of a difference-in-difference model since it includes one of the three two-way interaction terms (between minimum wages, states, and years) and does not include the three-way interaction term (between minimum wages, states, and years). We estimated the difference-in-difference counterpart for male employment and the results are qualitatively the same.

Table 1. **Full Sample Means by Gender**

	1983		2008	
	Men	**Women**	**Men**	**Women**
Employed for cash wages	0.189	0.087	0.328	0.119
	(0.392)	(0.282)	(0.470)	(0.324)
Educational attainment				
Illiterate	0.417	0.737	0.237	0.462
	(0.493)	(0.440)	(0.426)	(0.499)
Less than primary school	0.134	0.067	0.102	0.089
	(0.341)	(0.250)	(0.302)	(0.285)
Primary school	0.158	0.084	0.158	0.125
	(0.365)	(0.278)	(0.365)	(0.331)
Middle school	0.139	0.055	0.207	0.141
	(0.346)	(0.228)	(0.405)	(0.348)
Secondary school	0.113	0.043	0.135	0.088
	(0.316)	(0.202)	(0.342)	(0.284)
Graduate school	0.040	0.014	0.160	0.095
	(0.196)	(0.119)	(0.367)	(0.294)
Potential experience in years	23.875	26.002	22.154	24.623
	(14.780)	(14.533)	(15.684)	(15.921)
Potential experience squared/100	7.885	8.873	7.368	8.598
	(8.386)	(8.652)	(8.336)	(8.910)
Age in years	34.040	33.736	34.814	35.023
	(13.270)	(13.355)	(13.692)	(13.474)
Currently married	0.722	0.753	0.684	0.746
	(0.448)	(0.431)	(0.465)	(0.435)
Scheduled tribe or caste	0.256	0.283	0.291	0.287
	(0.436)	(0.450)	(0.454)	(0.452)
Hindu	0.843	0.856	0.831	0.834
	(0.364)	(0.351)	(0.375)	(0.372)
Household headed by a man	0.967	0.883	0.946	0.876
	(0.179)	(0.321)	(0.226)	(0.330)
Rural	0.733	0.789	0.735	0.747
	(0.442)	(0.408)	(0.442)	(0.435)
No. of preschool children in household	0.762	0.775	0.484	0.516
	(0.958)	(0.957)	(0.808)	(0.830)
No. of observations	391,157	244,302	221,443	212,877

Note: Standard deviations are in parentheses and sample means are weighted. All means are expressed in percentage terms unless otherwise noted.
Source: Authors' calculations.

markedly over time, especially for women. By 2008, the percentage of illiterate women had dropped to 46%, and the percentage of women with at least secondary schooling had risen to 18%. The data also show a sizable gender differential in geographical residence—73% of men lived in rural areas in 1983 compared with 79% of women. This difference shrank during the period but did not disappear. The bulk of the sample was married, lived in households headed by men, and claimed Hinduism as their religion. On average, between 25% and 30% of individuals belonged to the scheduled castes or tribes.

We merged the NSSO data with a separate database on daily minimum wage rates across states, industries, and years to create a database on state- and industry-level daily minimum wage rates using the annual *Report on the Working of the Minimum Wages Act, 1948* published by the Government of India's Labour Bureau. Only very recent issues of this report are available electronically; earlier years had to be obtained from local sources as hard copies and converted into an electronic database. For each year, we obtained the minimum wage report for the year preceding the NSSO data wave, whenever possible, in order to allow for adjustment lags. We were able to obtain reports for the following years: 1983 (1983 NSSO wave), 1986 (1987–1988 NSSO wave), 1993 (1993–1994 NSSO wave), 1998 (1999–2000 NSSO wave), 2004 (2004–2005 NSSO wave), and 2006 (2007–2008 NSSO wave).

We then merged the minimum wage data into the pooled NSSO data using state codes and industry codes aggregated into five broad categories (agriculture and forestry, mining, construction, services, and manufacturing). At least two-thirds of women were employed in agriculture during the period of analysis; for men, this share was closer to one-half. Men were more concentrated in construction, services, and manufacturing, while over time, women increased their relative representation in services. For any individuals in the full sample who did not report an industry to which they belonged, this merging process entailed using the median legislated minimum wage rate for each individual's state and sector (urban or rural) in a particular year. Assigning all individuals a relevant minimum wage regardless of their employment status allowed us to estimate minimum wage impacts on the likelihood of cash-based employment relative to all other types of activities, including those performed by individuals of working age who were not employed (and therefore did not report an industry).

For each of the broad categories defined above, we utilized the median minimum wage rate across the detailed job categories as most states had minimum wage rates specified for multiple occupations within the broad groups. Further, given that smaller states are combined with larger ones in order to maintain consistency in the NSSO data, utilizing the median rate across states, years, and job categories avoids problems with especially large or small values. Moreover, if values were missing for the minimum wage for a broad industry category in a particular state, we used the value of the minimum wage for that industry from the previous time period for which data was available for that state. Underlying this step was the assumption that the minimum wage data are recorded in a particular year only if states actually legislated a change in that year. Similarly, the minimum wages for the aggregate industry categories in a state that was missing all values were assumed to be the same as the minimum wages in this state in the preceding time period.

The 1983 and 1985–1986 minimum wage reports differed from subsequent years in several ways. First, these two earlier reports published rates for detailed job categories based on an entirely different set of labels. Hence, the aggregation procedure into the five broad categories involved reconciling the two different sets of labels. Second, the earlier reports published monthly rates for some detailed categories; these rates were converted to daily rates using the assumption of 22 working days per month. Third, the two earlier reports published numerical values for piece rate compensation, while the latter four reports simply specified the words "piece rate" as the compensation instead of providing a numerical value. For the two earlier reports, the piece rate compensation was converted into daily wage values using additional information in the reports on total output per day and minimum compensation rates. For the latter four reports, because very few detailed industries paid on a piece rate basis and those that did specified no numerical values, we assigned a missing value to the minimum wage rate. The two earlier reports also specified minimum wage rates for children; these observations were removed from the database of minimum wage rates because our NSSO sample consists only of individuals 15–65 years of age.

Also merged into the NSSO data were separate databases of macroeconomic and regulatory variables at the state level that capture underlying labor market trends. The variables cover 15 states for each of the 6 years of the NSSO data and include net real domestic product, unemployment rates, indicators of minimum wage enforcement, and indicators of the regulatory environment in the labor market. The domestic product data were taken from Reserve Bank of India (2014) and the state-level unemployment data merged into the sample were obtained from NSSO reports on employment and unemployment during each survey year (Indiastat various years, NSSO various years). Also merged into the full sample are four indicators of minimum wage enforcement by state and year. These indicators include the number of inspections undertaken, number of irregularities detected, number of cases in which fines were imposed, and total value of fines imposed in (real) rupees. The data on minimum wage enforcement are available from the same annual reports (*Report on the Working of the Minimum Wages Act, 1948*) that were used to construct the minimum wage rate database.

Finally, we control for two labor market regulation variables. The first variable (adjustments) relates to legal reforms that affect the ability of firms to hire and fire workers in response to changing business conditions. Positive values for this variable indicate regulatory changes that strengthen workers' job security through reductions in firms' ability to retrench, increases in the cost of layoffs, and restrictions on firm closures. Negative values indicate regulatory changes that weaken workers' job security and strengthen the capacity of firms to adjust employment. The second variable (disputes) relates to legal changes affecting industrial disputes. Positive values indicate reforms that make it easier for workers to initiate and sustain industrial disputes or that lengthen the resolution of industrial disputes. Negative values indicate state amendments that limit the capacity of workers to initiate and sustain an industrial dispute or that facilitate the resolution of industrial disputes. The underlying data are from Ahsan and Pagés (2009) and further discussion of

Table 2. **Average Daily Minimum Wage Rates by Industry and State**

Panel A: Nominal

	Agriculture		Mining		Construction		Services		Manufacturing	
	1983	**2008**	**1983**	**2008**	**1983**	**2008**	**1983**	**2008**	**1983**	**2008**
Andhra Pradesh	14.1	74.0	12.3	92.5	14.6	99.9	17.0	95.2	11.2	93.9
Assam	11.5	72.4	13.8	55.0	12.0	72.4	11.0	55.0	11.5	55.0
Bihar	9.3	77.0	14.1	77.0	18.8	77.0	20.9	77.0	14.0	77.0
Gujarat	15.2	94.1	14.9	93.0	16.3	95.3	15.1	95.1	14.9	94.7
Haryana	19.8	95.6	21.0	95.6	21.1	95.6	28.1	95.6	23.6	95.6
Karnataka	10.0	73.1	11.2	79.3	11.8	83.6	13.2	84.6	10.5	81.0
Kerala	7.5	101.0	6.6	276.2	17.1	165.7	13.5	123.0	7.9	114.6
Madhya Pradesh	10.7	79.0	10.7	95.0	14.3	95.0	15.9	95.0	17.0	95.0
Maharashtra	11.8	94.0	9.9	87.0	22.5	87.0	12.5	87.0	13.7	87.0
Odisha	9.5	55.0	15.3	55.0	15.3	55.0	15.1	55.0	17.0	55.0
Punjab	10.3	98.5	12.6	98.5	17.1	98.5	14.7	127.0	14.5	127.0
Rajasthan	22.0	73.0	22.0	80.4	22.0	73.0	22.0	73.0	22.0	73.0
Tamil Nadu	10.0	70.8	16.6	94.9	19.0	113.8	9.5	86.4	5.5	77.2
Uttar Pradesh	9.0	85.9	9.5	112.7	9.5	100.2	11.4	100.2	14.5	100.2
West Bengal	23.0	134.5	28.0	134.5	24.8	134.5	31.5	144.8	23.6	134.5

Panel B: Real

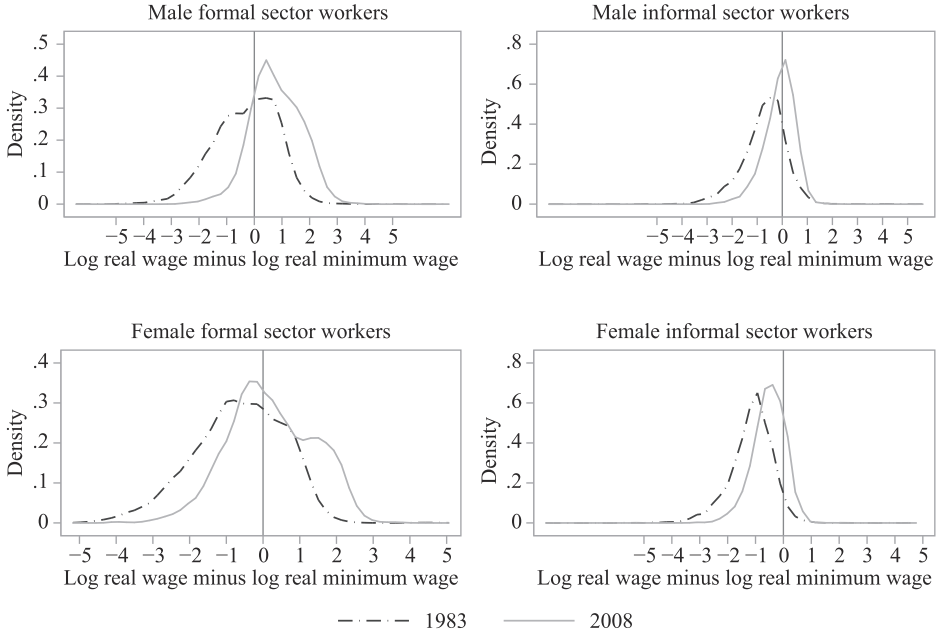
	Agriculture		Mining		Construction		Services		Manufacturing	
	1983	**2008**	**1983**	**2008**	**1983**	**2008**	**1983**	**2008**	**1983**	**2008**
Andhra Pradesh	14.1	14.9	12.3	18.6	14.6	20.1	17.0	19.2	11.2	18.9
Assam	11.5	14.6	13.8	11.1	12.0	14.6	11.0	11.1	11.5	11.1
Bihar	9.3	15.5	14.1	15.5	18.8	15.5	20.9	15.5	14.0	15.5
Gujarat	15.2	18.9	14.9	18.7	16.3	19.2	15.1	19.1	14.9	19.1
Haryana	19.8	19.2	21.0	19.2	21.1	19.2	28.1	19.2	23.6	19.2
Karnataka	10.0	14.7	11.2	16.0	11.8	16.8	13.2	17.0	10.5	16.3
Kerala	7.5	20.3	6.6	55.6	17.1	33.3	13.5	24.8	7.9	23.1
Madhya Pradesh	10.7	15.9	10.7	19.1	14.3	19.1	15.9	19.1	17.0	19.1
Maharashtra	11.8	18.9	9.9	17.5	22.5	17.5	12.5	17.5	13.7	17.5
Odisha	9.5	11.1	15.3	11.1	15.3	11.1	15.1	11.1	17.0	11.1
Punjab	10.3	19.8	12.6	19.8	17.1	19.8	14.7	25.6	14.5	25.6
Rajasthan	22.0	14.7	22.0	16.2	22.0	14.7	22.0	14.7	22.0	14.7
Tamil Nadu	10.0	14.3	16.6	19.1	19.0	22.9	9.5	17.4	5.5	15.5
Uttar Pradesh	9.0	17.3	9.5	22.7	9.5	20.2	11.4	20.2	14.5	20.2
West Bengal	23.0	27.1	28.0	27.1	24.8	27.1	31.5	29.1	23.6	27.1

Notes: Nominal wages in rupees, real wages are pegged to price indices with a base year of 1983. As a point of information, the average exchange rate was $1 = Rs44 in 2008.
Source: Government of India, Labour Bureau. Various years. *Report on the Working of the Minimum Wages Act, 1948*. Shimla.

the coding and interpretation of these variables is found in Menon and Rodgers (2013).

Table 2 presents sample statistics for average minimum wage rates by industry across states. In 1983, some of the highest legislated minimum wage rates were found in Haryana, Rajasthan, and West Bengal. By 2008, however, Haryana and Rajasthan had been replaced by Kerala, known for its relatively high social development

Figure 1. **Kernel Density Estimates of the Relative Real Wage across Formal and Informal Sector Workers in India**



Source: Authors' calculations.

indicators, and Punjab. Among industries, minimum wage rates tended to be the highest on average in construction, mining, and services, the first two of which are male-dominated industries. Rates tended to be the lowest in agriculture, which is where women are concentrated.

Figure 1 presents a set of wage distributions around the average statutory minimum wage in 1983 and 2008. The figure shows the distributions for male and female workers in India in the formal and informal sectors. Following convention, we construct the kernel density estimates as the log of actual daily wages minus the log of the relevant daily minimum wage for each worker, all in real terms (Rani et al. 2013). In each plot, the vertical line at zero indicates that a worker's wage is on par with the statutory minimum wage in his or her industry and state in that year, indicating that the minimum wage is binding and that firms are in compliance with the legislation. Weighted kernel densities are estimated using standard bandwidths that are selected nonparametrically.

Figure 1 shows that the wage distributions around the average statutory minimum wage are closer to zero in 2008 than in 1983 for both male and female workers. The shifts in the distributions suggest that compliance has increased over time with proportionately more workers engaged in jobs in which they are paid the legislated wage. For both men and women, the rightward shift in the wage distribution occurred in both the formal sector and the informal sector, which is consistent with the findings for other economies of a lighthouse effect in which informal sector wages increase when workers and employers use the minimum wage as a benchmark in wage negotiations. However, the improvement in compliance holds more for male workers as most of the distributions for female workers in 2008 are still to the left of the point that indicates full compliance. A higher degree of compliance for male workers holds for both the formal and informal sectors.

These kernel density graphs are important in that they depict relative positions of real wages in comparison to what is legally binding, with peaks at zero suggesting compliance by firms. Such compliance could come from a variety of sources, including better enforcement of laws (which is included in the regression models), better agency on the part of workers (which would result from increased worker representation and unionization), or a combination of these factors such as the sorting of workers into occupations that are subject to stronger enforcement and better representation. For example, Kerala's historical record of relatively high rates of unionization and worker unrest (Menon and Sanyal 2005) may underlie the state's apparently high rate of compliance as depicted in Figure A.1, which presents kernel density estimations for each state. The NSSO data do not allow for consistent controls for worker agency since questions on union existence and membership are not asked every year. However, the enforcement variables and the regulatory environment control variables should control for at least some of these effects.

We note two more issues related to sorting. First, workers might move across states seeking conditions that are more favorable for the occupations in which they are trained. Because questions about migration were not asked consistently in the 1983–2008 NSSO data, we cannot control for this directly. However, as noted above, rates of migration in India are generally quite low and state characteristics that could drive these types of movements are accounted for in the regression framework with the inclusion of state and time fixed effects and their interactions. Second, there may be sorting by workers into industries both across and within states depending on skill and training levels. Again, the NSSO modules do not consistently ask whether there were recent job changes or for the details of such changes (e.g., switches in industry affiliations). We control for possible sorting on observables by including a full set of education, experience, and demographic characteristics that conceivably influence choice of industries and possible movements between them. This approach is supported by recent work indicating that controlling for individual-level characteristics may absorb variations in both observable and unobservable attributes under certain circumstances (Altonji and Mansfield 2014).[6]

[6]Previous studies have used worker fixed effects to control for sorting on unobservables (see, for example, D'Costa and Overman 2014), but our data are repeated cross sections and not panel in nature.

Table 3. **Determinants of Employment and Wages for Men in the Rural Sector**

	Employment Probability		Log Wages	
Variable	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Minimum wage	0.634***	(0.078)	1.078***	(0.213)
Education (reference group = illiterate)				
Less than primary school	—0.061***	(0.009)	0.110***	(0.020)
Primary school	−0.063***	(0.008)	0.179***	(0.036)
Middle school	−0.059***	(0.013)	0.334***	(0.043)
Secondary school	−0.043**	(0.017)	0.736***	(0.067)
Graduate school	0.073**	(0.031)	1.237***	(0.086)
Years of potential experience	0.010***	(0.001)	0.036***	(0.002)
Potential experience squared/100	−0.017***	(0.001)	−0.047***	(0.004)
Currently married	0.053***	(0.008)	0.005	(0.021)
Scheduled tribe or caste	0.064***	(0.009)	−0.040**	(0.016)
Hindu	0.000	(0.008)	−0.047	(0.027)
Household headed by a man	−0.041**	(0.014)	−0.007	(0.045)
Number of preschool children	−0.005**	(0.002)	−0.004	(0.008)
Net state domestic product	0.002***	(0.000)	0.005***	(0.000)
State unemployment rate	0.009***	(0.001)	0.025***	(0.003)
State regulations: Adjustments	−0.019***	(0.006)	−0.147***	(0.028)
State regulations: Disputes	−0.024***	(0.004)	−0.025***	(0.005)
Enforcement: Inspections	0.030***	(0.003)	0.083***	(0.011)
Enforcement: Irregularities	−0.011***	(0.001)	−0.013***	(0.003)
Enforcement: Cases w/ fines	−0.085***	(0.011)	0.333***	(0.014)
Enforcement: Value of fines	0.008***	(0.001)	0.017***	(0.002)
No. of observations	1,216,259		218,506	

Notes: Weighted to national level with National Sample Survey Organization sample weights. Standard errors, in parentheses, are clustered by state. *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.10$. Both regressions include state dummies, time dummies, and state–time interaction terms.
Source: Authors' calculations.

IV. Results

Table 3 presents the regression results for the determinants of men's employment and wages in the rural sector. The results show that the real minimum wage has a positive and statistically significant impact on men's likelihood of being employed for cash wages in the rural sector. For a 10% increase in the real minimum wage, the linear probability of employment increases by 6.34% on average for men in rural areas of India. Other variables in these models show that the likelihood of employment falls with all levels of education up through secondary school, but then rises with a graduate education. The probability of cash-based employment for rural men is higher with potential experience, marriage, scheduled tribe or caste status, net state domestic product, state unemployment, and two measures of enforcement (inspections and value of fines). But the probability of cash-based employment in rural areas is lower in households that are male headed and in households with preschool children. It also falls with both measures of the regulatory environment and two measures of enforcement. On balance, it appears that all else being equal,

Table 4. **Determinants of Employment and Wages for Women in the Rural Sector**

	Employment Probability		Log Wages	
Variable	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Minimum wage	0.602***	(0.093)	0.687**	(0.248)
Education (reference group = illiterate)				
Less than primary school	−0.058***	(0.014)	0.097***	(0.030)
Primary school	−0.060***	(0.014)	0.161**	(0.066)
Middle school	−0.075***	(0.016)	0.199***	(0.044)
Secondary school	−0.043**	(0.018)	0.804***	(0.085)
Graduate school	0.084***	(0.022)	1.329***	(0.132)
Years of potential experience	0.005***	(0.001)	0.022***	(0.005)
Potential experience squared/100	−0.008***	(0.001)	−0.031***	(0.007)
Currently married	0.007*	(0.004)	−0.012	(0.013)
Scheduled tribe or caste	0.053***	(0.008)	0.028	(0.021)
Hindu	0.006	(0.008)	−0.006	(0.043)
Household headed by a man	−0.073***	(0.010)	−0.049	(0.033)
Number of preschool children	−0.005***	(0.002)	−0.010	(0.009)
Net state domestic product	−0.001***	(0.000)	0.003***	(0.000)
State unemployment rate	−0.003***	(0.000)	−0.001	(0.001)
State regulations: Adjustments	−0.076***	(0.016)	−0.230***	(0.044)
State regulations: Disputes	−0.039***	(0.003)	0.060***	(0.004)
Enforcement: Inspections	0.027***	(0.004)	0.036***	(0.011)
Enforcement: Irregularities	−0.003***	(0.000)	−0.004***	(0.001)
Enforcement: Cases w/ fines	−0.149***	(0.016)	0.146***	(0.032)
Enforcement: Value of fines	0.007***	(0.001)	0.002	(0.001)
No. of observations	963,269		85,753	

Notes: Weighted to national level with National Sample Survey Organization sample weights. Standard errors, in parentheses, are clustered by state. *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.10$. Both regressions include state dummies, time dummies, and state−time interaction terms.
Source: Authors' calculations.

the employment probability for men in the rural sector is negatively affected by a regulatory and enforcement structure that appears to be restrictive for employers.

Table 3 also reports results for real wages for men in the rural sector. The coefficient for the real minimum wage shows that for a 10% increase in the minimum wage, real wages rise by 10.78%. Relative to being illiterate, all levels of education have positive and statistically significant impacts on wages. As expected, wages rise with potential experience at a decreasing rate. Unlike with the case of employment, membership in one of the scheduled castes has a negative effect on real wages. Real wages also rise with net state domestic product and the unemployment rate. As one would expect, real wages for rural men rise with three of the four measures of minimum wage enforcement. Other labor regulations associated with adjustments and disputes have the opposite effect on real wages, suggesting that men experience a pay penalty in the face of a regulatory environment in which employers have more difficulty in adjusting the size of their workforce or ending disputes.

Table 4 presents results for the determinants of cash-based employment and wages for women in the rural sector. Like the results for men in the rural sector, women experience a positive impact on employment from the minimum wage. For a 10% increase in the real minimum wage, the linear probability of employment increases by 6.02% on average for women in rural areas. Although this estimate is smaller than the estimate for men in the rural sector, tests reveal that these coefficients are not statistically distinct. Lower levels of education are negatively associated with employment for women, but completing graduate school has a positive effect. The negative association may reflect the fact that women with lower levels of education are less likely to hold cash-based jobs in the rural sector. Married women and women who are members of the backward castes are more likely to be employed. In contrast, rural women are less likely to be employed if the household is headed by a man or if there are preschool-aged children in the household. In keeping with intuition, labor regulations that strengthen workers' ability to initiate or sustain industrial disputes are associated with lower levels of employment. As in the case with rural men, the enforcement variables that most directly affect firms (inspections and the value of fines) are positively related to women's likelihood of employment in the rural sector, while women's employment falls with both measures of the regulatory environment and the other two measures of enforcement.

Table 4 further indicates that for rural women receiving cash wages, the real minimum wage has a positive effect on wages. Controlling for state-level, time-varying heterogeneity, a 10% increase in the real minimum wage increases real wages by 6.87%. Although this increase is smaller than the 10.78% wage increase reported for rural men, the difference between the male and female coefficients is not statistically significant. Education has a positive impact on real wages, with higher levels of education associated with considerable wage premiums relative to having no education. Work experience matters positively, as does net state domestic product. Labor regulations associated with disputes have a beneficial impact on wages too. Among the enforcement variables, as with men, rural women's wages on balance are positively affected by minimum wage enforcement, with the number of cases with fines imposed having the largest positive impact.

Table 5, which reports results for the determinants of men's cash-based employment and wage levels in the urban sector, shows that the minimum wage rate has no statistically significant effect on these outcomes. This result most likely suggests that in urban areas, perhaps as a consequence of better enforcement and/or increased awareness on the part of workers, men are paid at least the legislated minimum wage. The absence of an impact on urban sector employment is similar to findings in numerous other studies, suggesting that India's urban sector labor market has characteristics consistent with those of other labor markets around the world.

The effect of the education variables in Table 5 are similar to those for men in the rural sector except that the positive effects of schooling on employment become evident at much lower levels of education. The positive employment impacts of potential experience, marriage, and membership in scheduled tribes or scheduled castes are also similar to those for men in rural India. However, in contrast to

Table 5. **Determinants of Employment and Wages for Men in the Urban Sector**

	Employment Probability		Log Wages	
Variable	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Minimum wage	0.132	(0.221)	0.247	(0.191)
Education (reference group = illiterate)				
Less than primary school	−0.024**	(0.010)	0.170***	(0.033)
Primary school	0.045***	(0.014)	0.248***	(0.045)
Middle school	0.078***	(0.019)	0.375***	(0.045)
Secondary school	0.110***	(0.022)	0.748***	(0.053)
Graduate school	0.197***	(0.019)	1.309***	(0.060)
Years of potential experience	0.018***	(0.001)	0.051***	(0.004)
Potential experience squared/100	−0.029***	(0.002)	−0.068***	(0.006)
Currently married	0.123***	(0.017)	0.179***	(0.027)
Scheduled tribe or caste	0.038***	(0.008)	−0.041**	(0.015)
Hindu	0.032***	(0.007)	−0.041**	(0.019)
Household headed by a man	−0.088***	(0.012)	0.014	(0.033)
Number of preschool children	−0.016***	(0.004)	−0.009	(0.011)
Net state domestic product	0.000	(0.000)	0.000*	(0.000)
State unemployment rate	0.001	(0.001)	−0.005***	(0.000)
State regulations: Adjustments	−0.015	(0.036)	−0.053	(0.031)
State regulations: Disputes	−0.009	(0.014)	0.046***	(0.010)
Enforcement: Inspections	0.000	(0.004)	0.007***	(0.002)
Enforcement: Irregularities	−0.002**	(0.001)	0.009***	(0.000)
Enforcement: Cases w/ fines	−0.052**	(0.022)	0.134***	(0.030)
Enforcement: Value of fines	0.002	(0.003)	0.000	(0.002)
No. of observations	690,342		239,534	

Notes: Weighted to national level with National Sample Survey Organization sample weights. Standard errors, in parentheses, are clustered by state. *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.10$. Both regressions include state dummies, time dummies, and state–time interaction terms.
Source: Authors' calculations.

their rural counterparts, Hindu men in the urban sector are more likely to be employed. Results for the other controls for men's wages in the urban sector in Table 5 are similar to the results for rural men. In particular, potential experience and higher levels of education are associated with substantial wage premiums. In contrast to their rural counterparts, the wages of urban men are positively impacted from marriage. Working against higher wages for urban men is membership in a disadvantaged caste and being Hindu. Finally, regulations associated with disputes have positive impacts on the wages of urban men as do three of the four enforcement measures.

Table 6 presents results for the determinants of cash-based employment and wages for women in the urban sector. Again, conditional on enforcement, real minimum wages have no statistically discernible impact on employment or wages. This result is similar to the finding for urban men and is in keeping with the intuition that India's urban sector labor market, despite its inefficiencies, operates more like labor markets in other economies where minimum wage laws have been found to have negligible impacts on aggregate employment and wages.

Table 6. **Determinants of Employment and Wages for Women in the Urban Sector**

	Employment Probability		Log Wages	
Variable	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Minimum wage	−0.342	(0.313)	0.432	(0.321)
Education (reference group = illiterate)				
Less than primary school	−0.053***	(0.014)	0.244**	(0.089)
Primary school	−0.055***	(0.014)	0.317***	(0.095)
Middle school	−0.046***	(0.014)	0.492***	(0.131)
Secondary school	0.017	(0.013)	1.107***	(0.108)
Graduate school	0.184***	(0.019)	1.663***	(0.071)
Years of potential experience	0.009***	(0.001)	0.048***	(0.005)
Potential experience squared/100	−0.015***	(0.002)	−0.065***	(0.008)
Currently married	−0.032***	(0.008)	0.136**	(0.051)
Scheduled tribe or caste	0.039***	(0.006)	0.078*	(0.039)
Hindu	0.011	(0.007)	0.006	(0.083)
Household headed by a man	−0.114***	(0.014)	−0.247***	(0.047)
Number of preschool children	−0.015***	(0.002)	0.002	(0.029)
Net state domestic product	0.001	(0.001)	0.001***	(0.000)
State unemployment rate	0.001	(0.001)	−0.001	(0.001)
State regulations: Adjustments	0.065**	(0.029)	−0.165***	(0.034)
State regulations: Disputes	0.018	(0.020)	0.029	(0.019)
Enforcement: Inspections	0.001***	(0.000)	0.008***	(0.002)
Enforcement: Irregularities	0.002	(0.002)	0.010***	(0.001)
Enforcement: Cases w/ fines	0.066	(0.077)	0.052	(0.078)
Enforcement: Value of fines	−0.004	(0.004)	0.003	(0.003)
No. of observations	462,224		53,828	

Notes: Weighted to national level with National Sample Survey Organization sample weights. Standard errors, in parentheses, are clustered by state. *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.10$. Both regressions include state dummies, time dummies, and state–time interaction terms.
Source: Authors' calculations.

For urban women, being married reduces the likelihood of employment but increases real wages, and women who live in households headed by men are less likely to be employed and to have lower real wages. Net state domestic product matters only for real wages. Labor regulations related to adjustments that are proworker in orientation have a positive impact on employment and a negative impact on wages for urban women. This result indicates that limitations imposed on firms' abilities to adjust their workforce help to protect urban women's jobs, but some of the cost may be passed along in the form of lower wages for women. Finally, the number of inspections to ensure enforcement has a positive effect on women's employment, while both inspections and the number of irregularities detected matter for their wages.[7]

[7]We combined five measures of enforcement and created an index (dummy) based on each measure exceeding its median value to create a single aggregate indicator for overall enforcement that varied by state and year. We then included this index in the models for Tables 3–6 in place of the disaggregated measures and added an interaction term of the legal minimum wage and this index, allowing us to determine the impact in states that have more stringent controls. Our results remain the same in the rural sector. However, in the urban sector, minimum wages marginally

Table 7. **Minimum Wage Coefficients from Employment Estimations across Sectors, before and after 2005**

	Men's Employment		**Women's Employment**	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**
Panel A. Formal sector				
Rural: Total	0.654***	(0.162)	0.696***	(0.165)
Rural: Pre-2005	0.655***	(0.162)	0.696***	(0.165)
Rural: Post-2005	0.414	(0.304)	0.844***	(0.265)
Urban: Total	−0.050	(0.324)	0.376	(0.297)
Urban: Pre-2005	−0.050	(0.324)	0.375	(0.297)
Urban: Post-2005	−0.358	(0.233)	0.773*	(0.435)
Panel B. Informal sector				
Rural: Total	−0.650***	(0.173)	−0.749***	(0.159)
Rural: Pre-2005	−0.651***	(0.173)	−0.748***	(0.159)
Rural: Post-2005	−0.402	(0.297)	−0.868***	(0.281)
Urban: Total	0.038	(0.328)	−0.374	(0.302)
Urban: Pre-2005	0.038	(0.328)	−0.374	(0.302)
Urban: Post-2005	0.353	(0.232)	−0.787*	(0.435)
Panel C. Self-employment				
Rural: Total	−0.084**	(0.033)	−0.016	(0.010)
Rural: Pre-2005	−0.084**	(0.033)	−0.016	(0.010)
Rural: Post-2005	−0.059	(0.035)	−0.006	(0.012)
Urban: Total	−0.010	(0.006)	−0.021***	(0.006)
Urban: Pre-2005	−0.010	(0.006)	−0.021***	(0.006)
Urban: Post-2005	−0.008	(0.010)	−0.001	(0.004)

Notes: Weighted to national level with National Sample Survey Organization sample weights. Standard errors, in parentheses, are clustered by state. $^{***} = p < 0.01$, $^{**} = p < 0.05$, $^{*} = p < 0.10$. Results are reported for the coefficient on the real minimum wage from separate regressions for whether or not an individual is employed in a particular sector (formal, informal, or self-employment). All regressions include the full set of control variables shown in Tables 3–6 plus state dummies, time dummies, and state–time interaction terms. Pre-2005 years are based on 1983 through 1999–2000 NSSO data, and post-2005 years are based on 2004–2005 through 2007–2008 NSSO data.
Source: Authors' calculations.

To shed more light on the employment results, minimum wage effects were estimated for different sectors of employment: formal sector, informal sector, and self-employment.[8] These results are found in Table 7 where only the minimum wage coefficients are reported.[9] Note that the estimations are performed using the sample of all individuals of working age who are employed for cash wages. Hence, results in Panel A represent the likelihood of formal sector employment relative to other types of employment in which people earn cash wages, where the formal sector includes those who reported their current employment status as

reduce employment and increase real wages for workers. Since this does not contradict the results in Tables 3–6, the results are not reported in this paper.

[8]We did not study wages in these disaggregated sectors as the concept of a wage is difficult to interpret for informal and self-employed workers.

[9]Complete regression results are found in Tables A.2a–c.

regular salaried employees. Similarly, Panel B reports the likelihood of informal sector employment relative to engagement in other cash-based employment, where the informal sector includes those who reported their current employment status as own-account workers, employers, unpaid family workers, casual wage laborers in public works, and casual laborers in other types of work.[10] In the same spirit, Panel C shows the likelihood of being self-employed relative to work in other employment with cash wages. Tabulations reveal that there is no overlap between formal sector employment and the other two categories of work. That is, formal sector status is mutually exclusive from informal sector status and self-employment. However, a small percentage of individuals are both self-employed and employed in the informal sector (about 2% of the sample).

Table 7 reports these results for the formal sector, informal sector, and self-employment using the full sample for each sector as well as subsamples differentiated by year. We divided the sample into the pre-2005 years (1983 through 1999–2000) and the post-2005 years (2004–2005 through 2007–2008) in an effort to gauge the impact of India's National Rural Employment Guarantee Act, 2005 (NREGA), a large job guarantee scheme that can be considered a mechanism for enforcing the minimum wage in rural areas. This act, which assures all rural households at least 100 days of paid work per year at the statutory minimum wage, has had a large positive effect on public sector employment in India's rural areas according to Azam (2012) and Imbert and Papp (2015). These two studies, however, have conflicting results for NREGA's effect with regard to gender. Azam (2012) finds that the act had a large positive impact on the labor force participation of women but not men, while Imbert and Papp (2015) found that the inclusion of proxy variables for other shocks unrelated to the program reversed this conclusion.

The aggregate results in Table 7 indicate that for both men and women, most of the positive employment effects observed for all rural sector individuals in the aggregate employment results come from formal sector employment. A possible explanation is the migration of industries to rural areas in order to take advantage of competitive wages (Foster and Rosenzweig 2004). Such industrial migration could also drive the results for the rural informal sector where a sizable disemployment effect is evident for both men and women. The results for self-employment are lower in magnitude and differ by gender; while rural men see small reductions in self-employment with increases in the minimum wage, it is urban women who exhibit the disemployment effect when it comes to this category of work.

The time-differentiated results in Table 7 reveal that in the formal sector, the positive and statistically significant impact of the minimum wage on the employment of rural men occurred mostly before 2005, while the impact occurred both before and after NREGA was implemented for rural women. Urban women in the formal sector also experienced an employment boost during the post-2005 years, suggesting

[10]We thank Uma Rani for guidance on India's definition of informal sector employment.

that minimum wage increases combined with a strict enforcement scheme helped to pull women into the formal labor market across the board, possibly due to spillovers of the scheme in urban areas. Similarly, Panel B shows that the disemployment effect for informal sector work among rural men occurred only before NREGA was implemented, while rural women showed a lower likelihood of informal sector employment with minimum wage increases both before and after its implementation. This negative employment effect from the minimum wage for women employed in the informal sector during the post-2005 years also extends to urban areas, though this is not the case for men.

In sum, minimum wages strengthened formal sector employment in rural areas for men and women. Potentially, there could be two reasons for this. First, employment elasticities could have increased for men and women. Second, this employment boost could be the direct impact of NREGA. The specification test results in Table 7 indicate that very little to none of the positive impact of minimum wages in the rural sector for men could be explained by NREGA. For women, some of the positive impact in the rural sector occurred before NREGA was implemented—suggesting a possible role for an increase in employment elasticities from another cause, perhaps as outlined in Foster and Rosenzweig (2004)—and some occurred after its implementation. The estimation is based on variation in minimum wage rates across states and industries, while NREGA was applied at the national level and did not vary by industry. Any variation in how states applied NREGA should be captured by the time-varying state control variables included in the specification, which implies that any impact that is measured net of these controls may be attributed separately to positive employment elasticities. This appears to be the case for rural men. However, some of the increase in women's formal employment in the rural sector after 2005 could be attributed to the enforcement mechanism built into NREGA. Although we are not able to pinpoint how much, we can be reasonably sure that the state control variables are picking up much of the employment effects of NREGA even though we do not include a specific NREGA-related variable in the models for Table 7. This conclusion is consistent with the argument in Imbert and Papp (2015) that some of the positive labor market outcomes for women ascribed to NREGA are actually due to changes unrelated to the program.

We further explored the positive employment results in rural areas by using the NSSO data to construct labor force participation rates by state, year, gender, and rural or urban areas; and we tested for the relationship between minimum wage rates and labor force participation rates with controls for state and year effects. These tests indicate that there is strong evidence of increased labor force participation rates in rural areas in states that have relatively high minimum wages.[11] Interestingly, when we added a gender dimension by interacting the minimum wage and a dummy variable for male workers, we found that for women, the increase in labor force

[11] The results are found in Table A.3.

Table 8. **Residual Wage Gap Covariates at the State Level**

	Coefficient Estimate
Minimum wage	0.128*
	(0.060)
Net state domestic product	0.001***
	(0.000)
Rural male unemployment	0.003***
	(0.001)
Urban male unemployment	−0.001
	(0.001)
Rural female unemployment	−0.001**
	(0.000)
Urban female unemployment	0.001
	(0.001)
State regulations: Adjustments	−0.005
	(0.016)
State regulations: Disputes	0.007
	(0.009)
Enforcement: Inspections	0.002**
	(0.001)
Enforcement: Irregularities	−0.006**
	(0.003)
Enforcement: Cases w/ fines	−0.032
	(0.047)
Enforcement: Value of fines	−0.002*
	(0.001)

Notes: Weighted to national level with National Sample Survey Organization sample weights. Standard errors, in parentheses, are clustered by state. *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.10$. All regressions have 90 observations at the state–year level and are estimated with an ordinary least squares regression. The residual wage gap is constructed with the pooled sample of male wage earners (458,040 observations) and includes controls for worker productivity characteristics, state dummies, year dummies, and state–year interaction terms.
Source: Authors' calculations.

participation rates in rural areas is higher than that for men in the post-2005 period in states with relatively high minimum wages. This result helps to explain the minimum wage effects we document in rural areas for women.

The final part of the analysis considers the impact of the minimum wage on the residual wage gap between men and women. The residual wage gap is estimated using the Oaxaca–Blinder decomposition procedure, a technique that decomposes the wage gap in a particular year into a portion explained by average group differences in productivity characteristics and a residual portion that is often attributed to discrimination (Blinder 1973, Oaxaca 1973). We used the coefficients from a regression of men's wages on the full set of worker productivity characteristics, state dummies, year dummies, and state–year interaction terms, estimated with the pooled sample of male wage earners (458,040 observations). The residual wage gaps are averaged to the state and year level and are regressed on controls that vary at this level: minimum wage, net state domestic product, gender- and sector-specific unemployment rates, regulatory environment in each state's labor market, and four measures of minimum wage enforcement.

The results in Table 8 indicate that the minimum wage is positively associated with the residual gender wage gap. A 10% increase in the minimum wage results in a 1.28% increase in the unexplained portion of the gender wage gap. This finding is consistent with the argument that noncompliance could be greater in the case of female workers, which is also evident in the kernel density figures for women.[12] Average wages are lower for women than for men, so the minimum wage is more binding and compliance is relatively costlier for them. This explains why firms might not fully comply with the legislated minimum wage for female workers, which is all the more likely in cases where enforcement is weak and the legal machinery for enforcing contracts is either inefficient or absent.

V. Conclusion

This study examined the extent to which minimum wage rates affect labor market outcomes for men and women in India. The empirical results indicate that regardless of gender, the legislated minimum wage has positive and statistically significant impacts on rural sector employment and real earnings. These positive impacts in rural areas occur primarily in the formal sector, with sizable disemployment effects observed for informal sector workers (especially women) and self-employed individuals (especially men). Hence, we find that a higher minimum wage appears to attract more employment for both genders in the formal sector in rural areas. This finding is not inconsistent with the studies reviewed above, especially those that have examined minimum wage impacts across wage distributions, sectors, and geographic areas and found employment growth in sectors and areas with high proportions of low-wage workers and relatively more underemployment (e.g., Stewart 2002). This finding is also consistent with evidence in Foster and Rosenzweig (2004) that a great deal of industrial capital moved to India's rural areas during this period to set up new enterprises that could employ relatively cheaper labor. Further, we cannot rule out that the positive employment results in the rural sector for women partly reflect the minimum wage enforcement mechanism built into NREGA.

In contrast, minimum wages in India's urban areas have little to no impact on overall employment or wages. These urban sector results are consistent with previous

[12]In kernel density graphs by industry, women in agriculture and services (the female-dominated industries in our sample) move closer to the line indicating full compliance between 1983 and 2008, but still earn below the level of full compliance at the end of the review period. This pattern is not observed for men, who by 2008 earn wages that are on par with those legislated by law.

work in both industrialized and developing economies. However, a closer look at different sectors within India's urban areas yields some evidence of disemployment effects for women who are self-employed or work in informal sector jobs, but not for men. These results suggest that NREGA may have drawn some urban women from informal sector jobs and self-employment.

Our study indicates that the main cost associated with India's minimum wage is an increase in the residual gender wage gap over the period 1983–2008. This widening in the gender wage gap is consistent with previous work that highlighted women's relatively weak position in the labor market after reforms, as well as studies that note the persistent clustering of women into low-wage jobs and pay inequities within the same jobs in India (Menon and Rodgers 2009). The relatively adverse impact of the minimum wage on women is also consistent with findings in advanced economies and in middle-income economies such as the PRC, Indonesia, and Mexico. The growing residual gender wage gap is most likely explained by weak compliance among firms that predominantly hire female workers. Noncompliance with minimum wage regulations that is widespread in developing economies is directly related to difficulties in enforcement. Our findings suggest that women may bear the burden of this lack of compliance.

For the minimum wage to be considered a gender-sensitive policy intervention in a shared prosperity approach to economic growth, governments must pay more attention to improving enforcement and compliance, especially in industries that employ large concentrations of female workers. Greater emphasis on compliance can help to prevent increases in the gender wage gap and ensure that the minimum wage is a more integral component in the toolkit to promote well-being. Policies that work in tandem to improve women's education and their experience in the workplace would help to complement these objectives and further strengthen the effectiveness of a statutory minimum wage.

A possible extension of this research would be to examine how India's minimum wage legislation has affected household well-being as measured by poverty incidence, household consumption, and human capital investments in children. For example, India has seen a steady decline in poverty since 1983, with an even stronger reduction among lower castes relative to more advantaged social groups (Panagariya and Mukim 2014). An interesting question is the extent to which the minimum wage may have contributed to reducing poverty and inequality.

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Appendix

Table A.1. **Variable Descriptions and Data Sources**

Description	Source and Years of Data
Individual and household characteristics	NSSO: 1983, 1987–1988, 1993–1994, 1999–2000, 2004–2005, 2007–2008
State-level net real domestic product	Reserve Bank of India: 1983, 1987, 1993, 1999, 2004, 2007
State-level unemployment rates	Indiastat; NSSO: 1983, 1987–1988, 1993–1994, 1999–2000, 2004–2005, 2007–2008
State-level indicators of minimum wage enforcement	Labour Bureau: 1983, 1986, 1993, 1998, 2004, 2006
State-level labor market regulations on adjustment and disputes	Ahsan and Pagés (2009): 1983, 1986, 1993, 1998, 2004, 2006
State- and industry-level minimum wages	Labour Bureau: 1983, 1986, 1993, 1998, 2004, 2006

Source: Authors' compilation.

Table A.2a. **Complete Regression Results for Employment Estimations in the Formal Sector, before and after 2005**

	Rural				Urban			
	Men		Women		Men		Women	
Formal Sector Results	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**
Minimum wage	0.655***	0.414	0.696***	0.844***	−0.050	−0.358	0.375	0.773*
	(0.162)	(0.304)	(0.165)	(0.265)	(0.324)	(0.233)	(0.297)	(0.435)
Education (reference group = illiterate)								
Less than primary school	0.066***	0.047***	0.038**	0.063***	0.187***	0.144***	0.136***	0.112
	(0.008)	(0.005)	(0.015)	(0.010)	(0.023)	(0.016)	(0.027)	(0.069)
Primary school	0.118***	0.110***	0.131***	0.104***	0.254***	0.234***	0.252***	0.145***
	(0.015)	(0.009)	(0.039)	(0.013)	(0.022)	(0.018)	(0.034)	(0.044)
Middle school	0.256***	0.232***	0.187***	0.230***	0.357***	0.335***	0.464***	0.230***
	(0.023)	(0.011)	(0.030)	(0.032)	(0.020)	(0.015)	(0.039)	(0.057)
Secondary school	0.524***	0.476***	0.607***	0.593***	0.534***	0.483***	0.602***	0.465***
	(0.027)	(0.022)	(0.031)	(0.048)	(0.028)	(0.023)	(0.043)	(0.054)
Graduate school	0.777***	0.776***	0.817***	0.868***	0.608***	0.591***	0.626***	0.545***
	(0.039)	(0.024)	(0.066)	(0.038)	(0.031)	(0.036)	(0.049)	(0.053)
Years of potential experience	0.015***	0.013***	0.007***	0.011***	0.007***	0.006***	0.000	0.005*
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)
Potential experience squared/100	−0.020***	−0.017***	−0.009***	−0.014***	−0.004	−0.006***	0.006*	−0.005
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.005)
Currently married	−0.020**	−0.038***	−0.016*	−0.037***	−0.006	−0.013	−.054***	−0.080***
	(0.008)	(0.008)	(0.009)	(0.007)	(0.010)	(0.012)	(0.017)	(0.020)
Scheduled tribe or caste	−0.052***	−0.078***	−0.006	−0.022***	−0.057***	−0.074***	−0.017	−0.006
	(0.011)	(0.016)	(0.009)	(0.005)	(0.016)	(0.013)	(0.012)	(0.018)
Hindu	0.014	0.014	0.013	−0.014*	0.034	0.028*	0.020	−0.017
	(0.013)	(0.016)	(0.011)	(0.007)	(0.020)	(0.015)	(0.023)	(0.025)
Household headed by a man	0.034	0.013	−0.015	−0.018	0.077***	0.034*	0.035	−0.014
	(0.030)	(0.013)	(0.010)	(0.011)	(0.024)	(0.017)	(0.040)	(0.015)

Continued.

Table A.2a. *Continued.*

	Rural				Urban			
	Men		Women		Men		Women	
Formal Sector Results	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**
No. of preschool children in household	−0.008*	−0.004	−0.005	0.007**	−0.017**	−0.021**	−0.004	−0.007
	(0.004)	(0.200)	(0.006)	(0.003)	(0.008)	(0.008)	(0.008)	(0.011)
Net state domestic product	−0.000***	−0.001	0.001***	−0.001***	0.000	0.001**	−0.000	−0.001
	(0.000)	(0.001)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.001)
State unemployment rate	0.007***	−0.009	−0.003***	−0.001**	0.002	−0.001	−0.001	−0.001*
	(0.002)	(0.005)	(0.001)	(0.000)	(0.006)	(0.002)	(0.001)	(0.001)
State regulations: Adjustments	−0.110***	−0.148*	−0.152***	−0.085**	−0.020	0.053	0.024	−0.107
	(0.028)	(0.083)	(0.048)	(0.030)	(0.021)	(0.050)	(0.030)	(0.080)
State regulations: Disputes	−0.039***	0.010***	0.068***	−0.078**	−0.004	0.071***	−0.007	−0.058
	(0.006)	(0.003)	(0.013)	(0.031)	(0.031)	(0.006)	(0.018)	(0.041)
Enforcement: Inspections	0.026***	0.002	0.012**	−0.010***	−0.004***	0.006***	0.018	−0.013*
	(0.007)	(0.002)	(0.004)	(0.003)	(0.000)	(0.001)	(0.012)	(0.007)
Enforcement: Irregularities	−0.009***	−0.048*	−0.008***	0.011	0.002	−0.021**	0.005***	0.001
	(0.002)	(0.023)	(0.002)	(0.010)	(0.004)	(0.009)	(0.001)	(0.010)
Enforcement: Cases w/ fines	−0.057**	. .	−0.103***	. .	0.050	. .	0.088***	. .
	(0.020)	. .	(0.017)	. .	(0.084)	. .	(0.014)	. .
Enforcement: Value of fines	0.007***	0.008	0.002***	−0.004***	−0.001	0.002	0.002	−0.005***
	(0.002)	(0.005)	(0.001)	(0.001)	(0.004)	(0.001)	(0.003)	(0.001)
No. of observations	140,354	78,152	57,831	27,922	182,426	57,108	39,203	14,625

Notes: Weighted to national level with National Sample Survey Organization sample weights. Standard errors, in parentheses, are clustered by state. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$. All regressions include state dummies, time dummies, and state–time interaction terms.
Source: Authors' calculations.

Table A.2b. **Complete Regression Results for Employment Estimations in the Informal Sector, before and after 2005**

	Rural				Urban			
	Men		Women		Men		Women	
Informal Sector Results	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**
Minimum wage	−0.651***	−0.402	−0.748***	−0.868***	0.038	0.353	−0.374	−0.787*
	(0.173)	(0.297)	(0.159)	(0.281)	(0.328)	(0.232)	(0.302)	(0.435)
Education (reference = illiterate)								
Less than primary school	−0.066***	−0.046***	−0.030	−0.061***	−0.189***	−0.141***	−0.133***	−0.108
	(0.008)	(0.005)	(0.019)	(0.009)	(0.023)	(0.017)	(0.029)	(0.067)
Primary school	−0.118***	−0.110***	−0.136***	−0.105***	−0.258***	−0.231***	−0.252***	−0.153***
	(0.015)	(0.009)	(0.042)	(0.013)	(0.022)	(0.019)	(0.036)	(0.047)
Middle school	−0.259***	−0.231***	−0.185***	−0.226***	−0.356***	−0.332***	−0.464***	−0.236***
	(0.023)	(0.011)	(0.032)	(0.030)	(0.020)	(0.015)	(0.040)	(0.053)
Secondary school	−0.531***	−0.473***	−0.600***	−0.595***	−0.538***	−0.480***	−0.606***	−0.468***
	(0.027)	(0.023)	(0.033)	(0.050)	(0.028)	(0.023)	(0.042)	(0.051)
Graduate school	−0.788***	−0.776***	−0.835***	−0.866***	−0.610***	−0.590***	−0.634***	−0.552***
	(0.043)	(0.025)	(0.058)	(0.040)	(0.032)	(0.035)	(0.051)	(0.051)
Years of potential experience	−0.015***	−0.013***	−0.007***	−0.011***	−0.007***	−0.006***	0.000	−0.005*
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)
Potential experience squared/100	0.020***	0.017***	0.009***	0.015***	0.004	0.006***	−0.006*	0.005
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.006)
Currently married	0.022**	0.037***	0.019*	0.036***	0.006	0.011	0.041**	0.075***
	(0.009)	(0.008)	(0.009)	(0.009)	(0.009)	(0.011)	(0.014)	(0.019)
Scheduled tribe or caste	0.051***	0.078***	0.000	0.021***	0.061***	0.072***	0.022	0.000
	(0.012)	(0.016)	(0.009)	(0.007)	(0.016)	(0.011)	(0.013)	(0.017)
Hindu	−0.014	−0.013	−0.017	0.013	−0.037*	−0.025	−0.027	0.016
	(0.012)	(0.017)	(0.010)	(0.008)	(0.020)	(0.015)	(0.026)	(0.024)
Household headed by a man	−0.027	−0.012	0.012	0.016	−0.078**	−0.033*	−0.026	0.013
	(0.027)	(0.012)	(0.011)	(0.013)	(0.027)	(0.017)	(0.037)	(0.015)

Continued.

Table A.2b. *Continued.*

	Rural				Urban			
	Men		Women		Men		Women	
Informal Sector Results	Pre-2005	Post-2005	Pre-2005	Post-2005	Pre-2005	Post-2005	Pre-2005	Post-2005
No. of preschool children in household	0.007*	0.004	0.005	−0.008*	0.017**	0.021**	0.004	0.008
	(0.004)	(0.300)	(0.004)	(0.004)	(0.007)	(0.008)	(0.008)	(0.011)
Net state domestic product	0.000***	0.001*	−0.002***	0.001***	−0.000	−0.001**	0.000	0.001
	(0.000)	(0.001)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.001)
State unemployment rate	−0.007***	0.010*	0.003***	0.001**	−0.002	0.001	0.001	0.001*
	(0.002)	(0.005)	(0.001)	(0.000)	(0.006)	(0.002)	(0.001)	(0.001)
State regulations: Adjustments	0.112***	0.153*	0.167***	0.070**	0.017	−0.054	−0.026	0.110
	(0.030)	(0.081)	(0.046)	(0.032)	(0.021)	(0.050)	(0.031)	(0.080)
State regulations: Disputes	0.038***	−0.008**	−0.072***	0.099***	0.004	−0.067***	0.008	0.067
	(0.007)	(0.003)	(0.012)	(0.032)	(0.032)	(0.006)	(0.018)	(0.041)
Enforcement: Inspections	−0.025***	−0.001	−0.013***	0.014***	0.004***	−0.006***	−0.019	0.015**
	(0.008)	(0.002)	(0.004)	(0.003)	0.000	(0.001)	(0.012)	(0.007)
Enforcement: Irregularities	0.008***	0.051**	0.009***	−0.026**	−0.002	0.019**	−0.006***	−0.004
	(0.002)	(0.023)	(0.002)	(0.010)	(0.004)	(0.009)	(0.001)	(0.010)
Enforcement: Cases w/ fines	0.062**	. .	0.112***	. .	−0.042	. .	−0.092***	. .
	(0.021)	. .	(0.016)	. .	(0.085)	. .	(0.014)	. .
Enforcement: Value of fines	−0.007***	−0.010*	−0.003***	0.005***	0.001	−0.002	−0.002	0.005***
	(0.002)	(0.005)	(0.001)	(0.001)	(0.005)	(0.001)	(0.003)	(0.001)
No. of observations	140,354	78,152	57,831	27,922	182,426	57,108	39,203	14,625

Notes: Weighted to national level with National Sample Survey Organization sample weights. Standard errors, in parentheses, are clustered by state. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$. All regressions include state dummies, time dummies, and state–time interaction terms.
Source: Authors' calculations.

Table A.2c. **Complete Regression Results for Employment Estimations for the Self-Employed, before and after 2005**

	Rural				Urban			
	Men		Women		Men		Women	
Self-Employed Results	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**
Minimum wage	−0.084**	−0.059	−0.016	−0.006	−0.010	−0.008	−0.021***	−0.001
	(0.033)	(0.035)	(0.010)	(0.012)	(0.006)	(0.010)	(0.006)	(0.004)
Education (reference group = illiterate)								
Less than primary school	0.005*	0.003	−0.001	0.005	−0.000	−0.000	0.002	0.006*
	(0.003)	(0.003)	(0.004)	(0.005)	(0.003)	(0.002)	(0.004)	(0.003)
Primary school	0.002	0.004	0.000	0.000	−0.000	−0.002	−0.002	−0.002*
	(0.004)	(0.005)	(0.004)	(0.002)	(0.002)	(0.002)	(0.004)	(0.001)
Middle school	−0.001	0.002	0.004	0.004	−0.003*	−0.001	−0.002	−0.002**
	(0.004)	(0.005)	(0.004)	(0.003)	(0.002)	(0.001)	(0.004)	(0.001)
Secondary school	−0.008*	−0.005	0.003	0.000	−0.003*	−0.003*	−0.005*	−0.003**
	(0.004)	(0.005)	(0.005)	(0.003)	(0.002)	(0.001)	(0.003)	(0.001)
Graduate school	−0.014***	−0.009**	0.002	0.001	−0.004*	−0.003**	−0.003	−0.003**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.002)	(0.001)	(0.002)	(0.001)
Years of potential experience	0.001**	0.001***	0.001*	0.001*	−0.000	−0.000	−0.000	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Potential experience squared/100	−0.001	−0.001	−0.001	−0.001*	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Currently married	0.012***	0.011***	−0.002	−0.001	0.002**	0.001	0.004**	0.001
	(0.003)	(0.002)	(0.004)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
Scheduled tribe or caste	−0.006**	−0.005*	−0.006	−0.001	−0.000	−0.000	−0.001	0.001
	(0.002)	(0.003)	(0.005)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Hindu	0.005**	0.004	0.004	0.004**	−0.000	0.000	−0.004	−0.001
	(0.002)	(0.003)	(0.003)	(0.002)	(0.001)	(0.001)	(0.003)	(0.002)
Household headed by a man	0.004	0.001	−0.006	−0.005***	−0.001	−0.001	−0.005	−0.002
	(0.006)	(0.002)	(0.007)	(0.002)	(0.003)	(0.001)	(0.004)	(0.001)

Continued.

Table A.2c. *Continued.*

	Rural				Urban			
	Men		Women		Men		Women	
Self-Employed Results	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**	**Pre-2005**	**Post-2005**
No. of preschool children in household	0.001	−0.001	0.001	0.000	0.000	0.001	0.000	−0.001
	(0.001)	(0.001)	(0.002)	(0.001)	(0.000)	(0.000)	(0.002)	(0.001)
Net state domestic product	0.000***	0.000***	0.000***	0.000***	0.000	0.000	0.001***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
State unemployment rate	−0.001**	0.001	0.000***	0.000	−0.001***	0.000	0.001***	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
State regulations: Adjustments	0.018***	0.021**	0.014***	0.003**	0.007***	0.003	0.003***	0.000
	(0.005)	(0.010)	(0.003)	(0.001)	(0.000)	(0.002)	(0.001)	(0.001)
State regulations: Disputes	0.010***	0.003***	0.001	0.002	0.005***	0.000	0.006***	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Enforcement: Inspections	−0.003**	−0.000	−0.000	0.000	0.001***	−0.000	0.000*	−0.000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Enforcement: Irregularities	−0.000	0.004	−0.000***	−0.001**	−0.000	0.001**	−0.002***	−0.001***
	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Enforcement: Cases w/ fines	−0.006	. .	0.005***	. .	0.002	. .	0.026***	. .
	(0.004)	. .	(0.001)	. .	(0.002)	. .	(0.000)	. .
Enforcement: Value of fines	−0.001***	−0.002**	−0.000	−0.000***	−0.001***	−0.000	−0.001***	−0.000***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
No. of observations	140,354	78,152	57,831	27,922	182,426	57,108	39,203	14,625

Notes: Weighted to national level with National Sample Survey Organization sample weights. Standard errors, in parentheses, are clustered by state. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$. All regressions include state dummies, time dummies, and state–time interaction terms.
Source: Authors' calculations.

Table A.3. **Labor Force Participation Rates and the Minimum Wage**

	Before 2005	**After 2005**	**Before 2005**	**After 2005**
High minimum wage state	−1.372	6.434**	−2.141	6.558**
	(6.363)	(2.706)	(7.051)	(2.734)
Male			−0.482	0.166*
			(0.413)	(0.078)
High minimum wage state			1.277	−0.240**
*Male			(1.795)	(0.108)

Notes: Weighted to national level with National Sample Survey Organization sample weights. Standard errors, in parentheses, are clustered by state. The notation *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$. All regressions include state dummies and time dummies.
Source: Authors' calculations.

Figure A.1. **Kernel Density Estimates of Relative Real Wages by State**

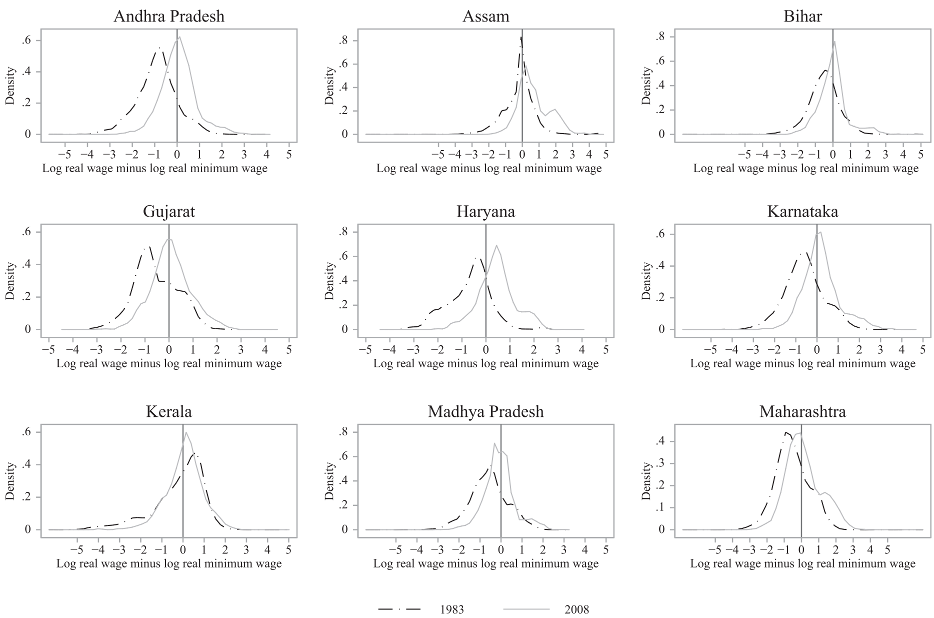
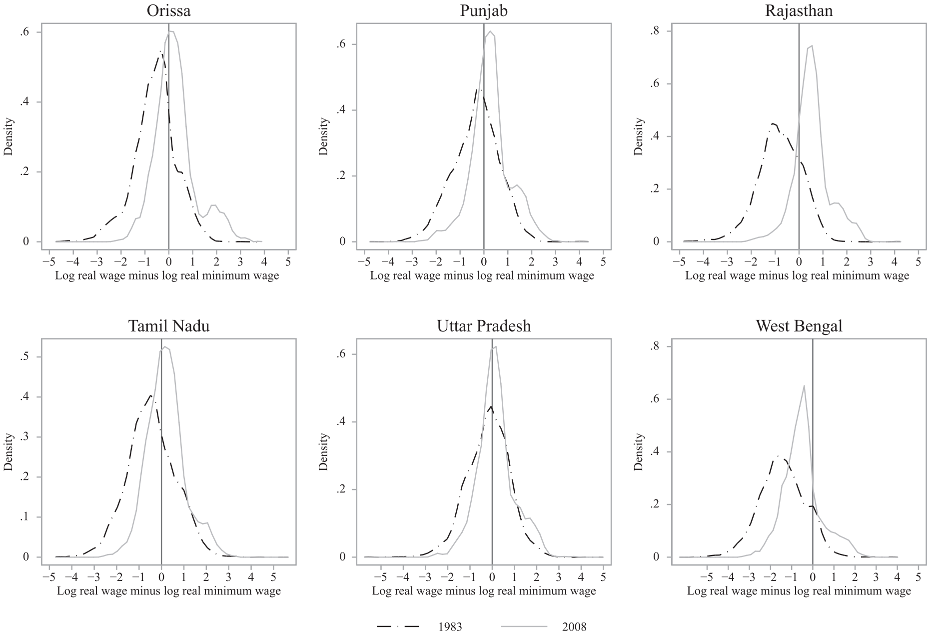


Figure A.1. *Continued.*



Source: Authors' calculations.

Do Factory Managers Know What Workers Want? Manager–Worker Information Asymmetries and Pareto Optimal Human Resource Management Policies

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GEORGE DOMAT, AND RAYMOND ROBERTSON*

This paper evaluates the conjecture that factory managers may not be offering a cost-minimizing configuration of compensation and workplace amenities by using manager and worker survey data from Better Work Vietnam. Working conditions are found to have a significant positive impact on global life assessments and reduce measures of depression and traumatic stress. We find significant deviations in manager perceptions of working conditions from those of workers. These deviations significantly impact a worker's perception of well-being and indicators of mental health. Such deviations may lead the factory manager to underprovide certain workplace amenities relative to the cost-minimizing configuration, which may in part explain the persistence of relatively poor working conditions in developing economies.

Keywords: apparel, human resource management, working conditions, Viet Nam
JEL codes: J32, J81, O15

I. Introduction

Human resource management (HRM) literature spanning more than 50 years reveals a significant debate over whether or not HRM (or strategic HRM) policies improve firm performance generally or induce specific worker responses such as loyalty or effort.[1] Hackman and Oldham (1976) find that specific job characteristics can put workers in a psychological state that motivates them to focus on work quality. Huselid's (1995) finding of a positive correlation between high-performance work systems and turnover, profits, and firm value suggests that

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[1]McGregor (1960) points out that firms may choose to view workers as either factor costs to be minimized or as talent that improves with investment.

positive worker responses increase firm performance. While the causality has been debated (see, for example, Wright et al. 2005), meta-analyses (Combs et al. 2006, Judge et al. 2001) and broad literature reviews (Croucher et al. 2013) suggest an emerging consensus of a positive relationship.

The necessary conditions for positive effects of HRM policies include the ability and willingness of managers to understand and implement such policies (Khilji and Wang 2006; Kuvaas, Buch, and Dysvik 2014) and that the HRM policies are congruent with worker preferences (Bowen and Ostroff 2004). This paper falls into the second category of findings and extends them by comparing worker and manager perceptions of the value workers place on different HRM policies using detailed manager and worker-level data from Viet Nam's apparel sector.

Working conditions in developing economies that are below international standards pose a significant challenge for international value chains. The argument that developing economy producers choose relatively poor conditions is often cited as evidence that such conditions are optimal for local producers. Economic theory, for example, suggests a cost-minimizing firm will divide monetary compensation and workplace amenities at the point where the marginal cost of an amenity is equal to the modal worker's marginal willingness to forgo earnings (Lazear and Gibbs 2009, Lazear and Oyer 2013).

Several factors may interfere with the firm's ability to construct the cost-minimizing compensation configuration of HRM policies. Firms that face binding capital constraints or find acquiring information about efficiency-enhancing investments in amenities to be costly or uncertain may underprovide amenities. Uncertainty, in particular, or a lack of information, in general, features prominently in recent research. Mezias and Starbuck (2003) suggest managers do not always have perfect information. Using experimental data from India, Bloom et al. (2013) show that informational barriers were the primary factors precluding the implementation of productivity-improving measures. From a theoretical perspective, Bowles (2004) concludes that firms will underprovide workplace amenities in a bargaining context in which supervisors imperfectly observe worker effort.

Imperfect information concerning the marginal value of workplace amenities may extend to workers as well. For some innovations, particularly those related to HRM, the employee must perceive and understand the organizational change the firm is attempting to implement. For example, the introduction of significant pay incentives will only increase productivity if employees understand the formula that rewards effort and the firm complies ex post with its ex ante pay commitments. Dunn, Wilson, and Gilbert (2003) report evidence that firms underprovide workplace amenities because workers themselves underappreciate the importance of workplace amenities ex ante when choosing employment. The implication is that comparisons between supervisor and worker perceptions should be based on contemporaneous data.

It may not be surprising, therefore, that several other studies find that firms underprovide nonpecuniary compensation to workers. For example, Herzog and Schlottmann (1990), analyzing United States Census data for the period 1965–1970, find that the willingness to pay in the form of forgone earnings for risk mitigation and workplace safety exceeds its marginal cost. Leblebici (2012) finds that 100% of employees strongly agree that supervisor relations affect their productivity. Helliwell, Huang, and Putnam (2009) and Helliwell and Huang (2010a, 2010b) find that firms appear to undervalue the importance of trust and workplace social capital. Moving 1 point on a 10-point workplace trust scale has the same effect on global life satisfaction as a 40% increase in income.

This paper presents a simple test for detecting errors in implementation of HRM innovations by comparing worker and manager perceptions of working conditions. The value of workplace innovations can be measured by estimating a standard hedonic equation that regresses a measure of worker well-being on wages and working conditions. Working conditions are measured first from the perception of workers and then from the perspective of the firm. The estimated coefficients in the hedonic equation when working conditions are measured from the perspective of the employee provide the true value to the firm of a workplace innovation once effectively implemented. The estimated coefficients when working conditions are measured from the perspective of the manager indicate the value of workplace innovations that the firm perceives. The difference between the coefficients provides a measure of the efficiency loss due to ineffective implementation.

Data collected during the monitoring and evaluation of Better Work Vietnam provide a novel opportunity to measure HRM implementation errors and their impact on the cost structure of apparel firms in global supply chains.[2] Survey responses from 3,526 workers and 320 factory managers in 83 apparel factories enrolled in Better Work Vietnam provide measures of worker well-being, wages, and working conditions from the perspective of both workers and managers. This allows us to empirically estimate a hedonic model of worker well-being using both worker perceptions of working conditions and manager perceptions, and then to compare the two.

Anticipating the results reported below, a broad range of workplace innovations as perceived by workers have a significantly higher impact on measures of worker well-being than innovations reported by human resource managers. The discrepancy strongly suggests that firms enrolled in Better Work Vietnam are failing to effectively implement innovations in which workers place a high value.

A theoretical framework is presented in section II, data in section III, and results in section IV. Conclusions and directions for future research follow.

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[2]Better Work is a program developed by the International Labour Organization and the International Finance Corporation. Firms are monitored against core standards and local labor law. Additional information is available at http://betterwork.org/global/

II. Theoretical Framework

Profit-maximizing HRM requires that factories allocate resources to a package of compensation and workplace amenities to minimize the cost of providing employees a reservation level of workplace satisfaction. If labor markets are perfectly competitive, the cost of the reservation compensation package will be equal to the employee's marginal revenue product. To model this formally, we begin with the assumption that a firm will choose a vector of compensation components, *B*, to minimize the cost of inducing work effort by an employee.[3] For a factory with two compensation components, B_1 and B_2, the cost-minimizing problem is

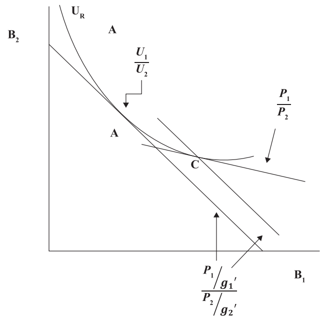
$$\min_{\{B_1, B_2\}} P_1 B_1 + P_2 B_2 + \lambda[U\{g_1(B_1), g_2(B_2)\} - U_R] \tag{1}$$

where P_i (i = 1, 2) is the cost to the firm of providing benefit B_i, and U_R is the reservation utility necessary to induce the representative worker to accept employment. Identifying the cost-minimizing compensation configuration will require the firm to know how workers value different types of benefits and amenities. Therefore, g_i is a function that reflects the worker's perception of any working condition, B_i, as perceived by the firm. The λ represents the Lagrange multiplier. The first order conditions for the program in equation (1) imply that

$$\frac{P_1/g_1'}{P_2/g_2'} = \frac{U_1}{U_2} \tag{2}$$

The condition in equation (2) is depicted at point A in the figure below.

Cost-Minimizing Working Conditions



Source: Author's illustration based on equation (2).

[3]In our model, we do not distinguish between the incentives of owners and managers. For the dimension of management that we are studying, the design of HRM schemes, this seems like a plausible assumption since owners will observe factory costs and we are assessing a one-time or periodic design of HRM systems rather than a continuous effort.

Firms may make two errors in attempting to locate point A. The first, of course, is that the firm may simply lack information on the marginal rate of substitution (U_1/U_2). However, consider the possibility that the firm manager has collected information on the relative valuation placed on each workplace amenity B_i by the firm's employees but may not know how workers perceive working conditions as given by g_i. In this case, the firm will attempt to set the cost-minimizing bundle according to

$$\frac{P_1}{P_2} = \frac{U_1}{U_2} \tag{3}$$

as indicated by point C. Here, we have assumed that the firm particularly underappreciates the small size of g_1'. The true cost of achieving reservation utility U_R is higher at compensation configuration C than at the efficient bundle A, given imperfect implementation.

The slope of the indifference curve in the figure is determined by the relative weights that workers place on wages, benefits, and workplace amenities. We employ a hedonic model to estimate these preferences by predicting measures of individual worker well-being, U_{ij}, which is a function of the following compensation components:

$$U_{ij} = \alpha_0 + \alpha_W B_{ij} + \gamma X_{ij} + \mu Z_j + \varepsilon \tag{4}$$

where B_{ij} is a vector of workplace amenities as perceived by worker i in factory j, X_{ij} is a vector of characteristics of worker i in factory j, and Z_j is a vector of characteristics for factory j. The estimated coefficients on the compensation components reveal the weights that workers associate with different compensation components in terms of well-being.

To compare differences between worker and manager perceptions of working conditions, we replace information on working conditions as reported by workers with information on working conditions as reported by human resource managers. The dependent variable remains a measure of self-reported worker well-being. However, workplace characteristics are reported by the factory human resource manager as given by B_j in equation (5):

$$U_{ij} = \alpha_0 + \alpha_M B_j + \gamma X_{ij} + \mu Z_j + \varepsilon \tag{5}$$

Given that $B_{ij} = g_{ij}\left(B_j\right)$ from equation (1), it follows that $\alpha_M = g'\alpha_W$. Thus, a measure of working conditions transmission fidelity can be measured by $g' = \frac{\alpha_M}{\alpha_W}$.

In estimating equation (4), there is a possibility of reverse causality. For example, poor mental health may affect the perception of a hostile work environment.

Better Work compliance assessments provide an alternative measure of working conditions. We then use Better Work compliance assessment data to measure β_j as in equation (6):

$$U_{ij} = \alpha_0 + \alpha_C \beta_j + \gamma X_{ij} + \mu Z_j + \varepsilon \tag{6}$$

Estimating equations (4), (5), and (6) generates a set of coefficients on working condition indices from the perspective of workers, managers, and Better Work compliance assessments. The coefficients provide a measure of the relative importance to workers of each working condition at the present level, relative to other working conditions. A difference in magnitude of the worker coefficient and the manager coefficient indicates discrepancies in implementation of workplace amenities and components of working conditions. For example, if the coefficient from the worker's perspective on a particular index is twice the magnitude of the same coefficient from the manager's perspective, then the implementation of that working condition is half as effective as the manager believes.

The factory may address a problem of implementation in two ways. It can either increase the quantity of a benefit or working condition that is poorly implemented or it can improve its implementation of that benefit. A factory intervention program could therefore improve the efficiency in a factory by finding differences in perceptions of implementation and providing benefit levels that more closely match worker perceptions.

Below, a two-step procedure is used to construct the working condition aggregates from the survey and compliance data. In the first step, working conditions as reported by workers, human resource managers, and compliance assessments are aggregated into indices of working conditions. Factor analysis is then applied to identify the underlying HRM systems. Equations (4), (5), and (6) are each estimated using the indices and underlying factors.

We use two different measures of worker well-being as dependent variables. The first is a global life satisfaction assessment and the second is a mental health index comprised of five indicators of depression including feelings of sadness, restlessness, hopelessness, fear, and instances of crying.

The independent variables are indices of working conditions including information on wages, regularity of pay, information provided to workers, pay structure, training, verbal and physical abuse, sexual harassment, working time, issues related to freedom of association and collective bargaining, occupational health and safety, and health services provided by the factory. Differences in factories unrelated to the compensation package are controlled for using an index of factory characteristics. Factory characteristics include number of employees and the ratio of workers to managerial employees. Additionally, worker demographic controls include gender, marital status, education level, self-perceived health status, age, and number of family members living in the household. Clark (2010) finds that after controlling for these worker characteristics, levels of happiness among similar workers are comparable within an economy, which is an assumption we make in the subsequent analysis.

Each independent variable of interest is represented by an index with values between 0 and 1. The resulting coefficient on each index will therefore be interpreted as the relative value the worker places on each working condition, holding other characteristics constant.

III. Data

When a factory enters the Better Work Program, Better Work Enterprise Advisors visit the factory to collect information about the factory's compliance with labor standards and working conditions before implementing any other program elements or training. At some point after enrollment, an independent research team visits the factory from Better Work's monitoring and evaluation program (separately from the Better Work Enterprise Advisors). The data used in the analysis below were collected during these independent worker and manager surveys undertaken in Vietnamese apparel factories from January 2010 through August 2012.

A total of 3,526 workers were surveyed at 83 factories, with no nonresponses among factories or managers. Thirty-three of these factories had an additional round of surveys taken after having participated in the program for approximately 1 year. In each factory, 30 randomly selected workers and four factory managers (general manager, human resources manager, financial manager, and industrial engineer) undertook a self-interview via a computer program loaded onto a PC tablet, again with no nonresponses. In our hedonic regressions, the managers' survey responses on working conditions are matched with the workers in their factory.

The population surveyed was not a random sample of workers in the Vietnamese apparel industry. Firm enrollment in Better Work Vietnam is voluntary and workers who are randomly selected have the option to refuse to participate. Limiting analysis to a self-selected group of apparel factories focuses specifically on those factories that are attempting to achieve a competitive advantage by developing a record of compliant behavior. However, there is little cross-worker variation in wages in the apparel sector. As a consequence, the contribution of monetary income to worker well-being may not be detected by the statistical analysis.

The worker survey includes information about households and family composition, health, compensation, benefits, training, working conditions, workplace concerns, mental well-being, and life satisfaction. The human resource manager survey asks questions about the factory's human resource practices including hiring, compensation, and training. This survey also asks about manager perceptions of worker concerns with factory conditions and practices.

Table 1. **Worker Characteristics**

	%
Gender	
Female	81.71
Male	18.29
Current Marital Status	
Never married	44.02
Married	54.19
Widowed divorced or separated	1.79
Highest Level of Education	
No formal education	0.70
Primary school	12.06
Lower secondary school	57.95
Upper secondary school	24.76
Short-term technical training	0.33
Long-term technical training	0.91
Professional secondary school	2.01
Junior college diploma	0.64
Bachelor’s degree	0.64
Rate Overall Health	
Very good	18.68
Good	44.71
Fair	36.36
Poor	0.24

Source: Authors’ calculations.

A. Worker and Manager Data

A summary of worker demographics can be found in Table 1. Over 80% of workers in the survey are female and over 50% are married. Around 87% of workers have completed at least lower secondary school, nearly a third of whom have completed upper secondary school as well. Only 65% of workers consider themselves to be in good or very good health, and almost a quarter consider their children’s health to be only fair or poor. Over 50% of workers occasionally experience severe headaches and 20% of workers occasionally experience severe stomach pain (Better Work Monitoring and Evaluation 2011).

1. Worker Well-being

Following Lazear and Gibbs (2009), participants were asked to rate their global life satisfaction on a 5-point scale. Table 2 contains a summary of worker responses. In measures of worker well-being, almost three-quarters of workers stated that they are either satisfied or very satisfied with their lives. Measures of mental well-being were selected from the Harvard Symptoms Checklist (Mollica et al. 1987) and include feelings of sadness, crying easily, feeling restless, feeling fearful,

Table 2. **How Satisfied Are You with Your Current Life?**

	%
Don't want to answer	0.09
Very satisfied	20.14
Satisfied	52.79
Somewhat satisfied	19.50
Somewhat unsatisfied	6.99
Not satisfied at all	0.49

Source: Authors' calculations.

Table 3. **How Much Have You Been Bothered or Troubled by the Following?**

	Feeling sad	**Crying easily**	**Feeling hopeless about the future**	**Restless, unable to sit still**	**Feeling fearful**
Don't want to answer	0.15	0.09	0.09	0.09	0.12
Not at all	73.33	82.29	86.54	88.61	87.97
A little of the time	18.89	13.09	10.51	8.81	8.90
Some of the time	6.29	4.25	2.13	2.13	2.49
Most of the time	1.18	0.21	0.55	0.30	0.39
All of the time	0.15	0.06	0.18	0.06	0.12

Notes: Numbers represent percentages of responses. Columns sum to 100.
Source: Authors' calculations.

or feeling hopeless about the future. Table 3 contains a summary of responses for the mental well-being variables. Though a quarter of workers reported feeling sad a little or some of the time, more than 80% of workers reported that they are not troubled by crying easily. More than 85% of workers said that they do not feel restless, fearful, or hopeless about the future (Better Work Monitoring and Evaluation 2011).

2. Wages

In 66% of factories, managers stated that 100% of workers are paid hourly. Only 20% of workers stated that their pay is determined by a piece rate. Thirty percent of workers reported that they have a production quota set by their supervisor. Factory managers state that piece rate pay is a concern for employees in 25% of factories and that the explanation of the piece rate is a concern in 14% of factories. Fifteen percent of employees stated that the piece rate is a concern and 7% of employees stated that the explanation of the piece rate is a concern for workers in the factory. Managers said that low wages are a concern in over 23% of factories, while only 17% of workers expressed concerns with low wages. Similarly, though 10% of factory managers stated that late payment of wages is a concern, only 5% of workers articulated their concerns with late payments (Better Work Monitoring and Evaluation 2011).

3. Concerns with Abuse, Occupational Safety, and Health

Managers stated that workers are concerned with verbal abuse in over 20% of factories, while physical abuse was reported as a concern in less than 7% of factories. Almost 10% of workers expressed concerns with verbal abuse and 3% of workers reported concerns with physical abuse or sexual harassment (Better Work Monitoring and Evaluation 2011).

While almost 30% of managers reported that workers have concerns with factory temperature, only 12% of workers expressed similar concerns. Around 15% of factories reported concerns with accidents or injuries, though less than 5% of workers reported similar concerns. Less than 8% of factories reported that workers have concerns with air quality or bad chemical smells, while 9% of workers expressed concerns with air quality and over 10% of workers expressed concerns with bad chemical smells (Better Work Monitoring and Evaluation 2011).

4. Training

Though over 90% of factory managers said that they have some sort of induction training for new workers that includes information on work hours, overtime, safety procedures, and equipment, less than half of workers said that they received any type of training other than in basic skills when they began working in the factory. Managers stated that information on items such as incentives and pay structure are included in less than 50% of factory induction training programs. Half of the managers surveyed said that 50% or more of their sewers had been trained in new sewing skills or quality control in the last 3 months, but no more than 7% of workers stated that they had gone through any type of training in the past 6 months (Better Work Monitoring and Evaluation 2011).

5. Worker–Manager Relations

Over 75% of workers stated that they would be very comfortable seeking help from a supervisor, but only half of workers stated that they felt treated with fairness and respect when a supervisor corrected them. Only 37% of workers stated that their supervisor followed the rules of the factory all of the time.

One hundred percent of factories report having a trade union representative, which is typical for Viet Nam, but only 52% of factory managers thought that the trade union representative would be very effective in helping resolve a conflict between managers and workers. At least 70% of factories have worker committees, but only 45% of factory managers thought that a worker committee would be effective in helping resolve a conflict. Almost 90% of workers are represented by a collective bargaining agreement (Better Work Monitoring and Evaluation 2011).

B. Coding the Worker and Manager Data

All responses to questions for the worker and manager surveys were fitted to a scale that ranges from 0 to 1. This process differed slightly for each question depending on the type of question. For all questions, answers nearer to 1 reflect a more desirable working condition.

There are four different types of questions on the surveys: (i) binary (yes or no), (ii) multiple-choice questions with mutually exclusive answers, (iii) questions where the participant is prompted to check all that apply, and (iv) open-ended questions. Each of these was coded as follows:

Yes or no questions. The more desirable response was coded as a 1 and the other response as a 0.

Multiple-choice questions. Responses were first ordered from least desirable to most desirable and then divided by the number of possible responses. This category includes all questions pertaining to concerns despite the fact that they were instructed to choose all that apply. The reason is that the possible responses could still be rated from least severe to most severe. Thus, the most severe response given is the most relevant.

Multiple-response questions. The number of responses selected by the participant was divided by the total number of possible responses. If the responses were negative aspects of working conditions, the score was then subtracted from 1.

Open-ended questions. These questions solely dealt with wages. Hence, each worker's reported wage was divided by the highest paid worker's wage.

C. Constructing Indices

The subclusters of working conditions identified by Better Work guided the construction of aggregates from the worker and manager surveys. Within subclusters, the mean of the questions was taken to be the score for that aggregate. This yielded 21 aggregates from the worker survey and 16 aggregates for the managers from which we work with an overlapping set of 15 working condition aggregates. These include issues related to child labor, paid leave, and contracting procedures. The components of the indices are reported in Tables A.1 and A.2 of the Appendix for workers and managers, respectively, and in the summary statistics in Table 4. Wage, gender discrimination, forced labor, collective bargaining, and chemical hazards are the most favorable conditions from worker perspectives. The ratio of temporary to permanent workers, training, and concerns about the method of pay are the least favorable. Except for health services and in-kind compensation, managers perceive less variation in working conditions than workers.

Table 4. **Summary Statistics**

Variable	Worker Concerns Obs.	Worker Concerns Mean	Worker Concerns Std. Dev.	Manager Perceptions of Worker Concerns Obs.	Manager Perceptions of Worker Concerns Mean	Manager Perceptions of Worker Concerns Std. Dev.
Wage concern index	5,790	0.961	0.129	305	0.874	0.244
Bonus concern index	5,874	0.652	0.123	305	0.948	0.161
In-kind compensation and benefits index	5,864	0.667	0.114	305	305	0.652
Pay transparency index	5,878	0.845	0.101	305	305	0.667
Training index	5,855	0.304	0.280	305	0.739	0.164
Gender discrimination index	5,863	0.939	0.165	305	305	0.123
Forced labor index	5,880	0.988	0.049	305	0.972	0.111
CBA index	5,627	0.909	0.288	305	0.814	0.177
Chemical hazard index	5,860	0.982	0.078	305	305	0.109
Health services index	5,881	0.672	0.120	305	0.518	0.243
Equipment safety index	5,872	0.991	0.051	305	305	0.054
Environment index	5,877	0.971	0.080	305	0.916	0.152
Temporary to permanent worker index	5,323	0.178	0.168	305	305	0.168
Method of pay index	5,880	0.493	0.064	305	0.943	0.163

CBA = collective bargaining agreement.
Source: Authors' calculations.

Compliance data are stratified into eight clusters that are further divided into 38 subclusters. All of the compliance questions are simple yes or no questions. Hence, the compliance score is the mean of all the questions that belonged to a specific subcluster. The means of all the subclusters within a cluster are calculated to obtain that cluster's score. Subcluster means were excluded when data were missing or exhibited zero variance across all factories. For example, among the child labor subclusters the variance was nearly zero. Therefore, only the broad cluster of child labor was included when performing the analysis on the subclusters. Note that there are more aggregates for compliance data than for the worker and manager surveys. The reason is that there are several points that are covered in the compliance data that are not covered in the surveys. These include issues related to child labor, paid leave, and contracting procedures.

Control variables include worker demographics and an index controlling for the size of the factory, which is composed of questions pertaining to how many full-time and part-time workers are in a factory.

IV. Empirical Results

Specifications are estimated with ordinary least squares.[4] Two indicators of worker well-being, life satisfaction and worker well-being, serve as the dependent variables. There are three sources of working conditions: worker survey, manager survey, and compliance assessment.

[4]Results are qualitatively similar when using ordered logits.

Every regression equation includes a common set of worker demographic and factory controls. Control variables include the factory size index in addition to the gender of the worker, age, education, general health, marital status, and number of people living in their household. It is worth noting that selection on unobservables remains a concern: if workers with better unobservables have both higher life satisfaction and are sorted in better jobs, this would tend to induce a correlation between working conditions and well-being.

Controlling for age and education addresses the observable dimension of this sorting, but not the unobservable dimension.

A. Worker Perceptions of Working Conditions

Consider first the estimation of equation (4): life satisfaction and worker well-being for which working conditions are measured based on worker perceptions as reported in the worker survey. Findings are reported in columns (1) and (2) of Table 5.

First, the coefficient on the wage is statistically significant only in the worker well-being equation. In a hedonic equation, the coefficient on the wage is usually used to place a monetary value on the other working conditions, which then is possible for well-being but not worker satisfaction. One possible explanation is that there is limited wage variation in this data set, therefore the lack of statistical significance is not entirely surprising.

Second, working conditions appear to have a stronger effect on life satisfaction than on mental well-being: working conditions have a statistically significant effect for seven indices in column (1) compared to four in column (2). Furthermore, for three of the four indices that are significant for well-being (wage concerns, pay transparency, and health services), the magnitude of the impact on satisfaction is larger. This is not surprising given that the worker well-being questions are intended to identify participants that are suffering from various degrees of depression. These results suggest that poor working conditions may affect a global sense of life satisfaction even before workers begin to experience symptoms of depression.

Turning to the indices themselves, eight working condition factors in the life satisfaction equation reported in column (1) are significant at a 10% level or higher. However, they are not all positive. Lack of wage concerns, access to health services, pay transparency, collective bargaining, and the environment index are positive. Training, gender discrimination, and equipment accidents are negative. However, these negative impacts are not statistically significant in column (2) for worker well-being.

The negative effect of training is understandable if training is undertaken in a hostile tone or is perceived as disciplinary in nature. Explaining the environmental index is more challenging. One would expect that fear of dangerous equipment and

Table 5. **Life Satisfaction and Worker Well-being—Worker and Manager Perceptions**

	Worker Perception		Manager Perception		Transmission Index	
Variables	**Worker Satisfaction (1)**	**Worker Well-being (2)**	**Worker Satisfaction (3)**	**Worker Well-being (4)**	**Satisfaction (5)**	**Well-being (6)**
Annual wage	0.269	0.194***	0.0882	0.0577**	**0.327**	0.297
	(0.172)	(0.0650)	(0.0992)	(0.0229)	0.0136	0.865
Wage concern index	1.091***	0.407***	0.142	0.0717	**0.130**	0.176
	(0.141)	(0.0959)	(0.167)	(0.0525)	0.000	0.724
Bonus concern index	−0.358**	0.0831	−0.272	−0.237**	0.760	−2.851
	(0.141)	(0.0695)	(0.345)	(0.0954)	0.689	0.846
In-kind compensation and benefits index	−0.0898	0.0549	−0.323	0.0797	3.594	1.452
	(0.186)	(0.0676)	(0.345)	(0.189)	0.634	0.300
Pay transparency index	0.303*	0.216***	0.416**	−0.0435	1.375	−0.201
	(0.170)	(0.0634)	(0.196)	(0.0994)	0.624	0.395
Training index	−0.286***	−0.0329	0.0378	0.0532	−**0.132**	−**1.615**
	(0.0578)	(0.0265)	(0.202)	(0.0984)	0.0110	0.000
Gender discrimination index	−0.325***	0.00278	−0.289	−0.227	0.891	−81.49
	(0.0659)	(0.0380)	(0.479)	(0.268)	0.873	0.000
Forced labor index	0.158	0.370**	0.0720	−0.0114	0.456	−**0.0307**
	(0.272)	(0.155)	(0.428)	(0.142)	0.730	0.000
CBA index	0.102**	0.00776	0.384	0.167	**3.757**	21.51
	(0.0402)	(0.0165)	(0.233)	(0.103)	0.143	0.956
Chemical hazard index	0.0430	0.178	0.212	−0.215	4.920	−1.208
	(0.269)	(0.142)	(0.438)	(0.280)	0.884	0.851
Health services index	0.813***	0.184***	−0.0140	−0.0760	−**0.0172**	−**0.414**
	(0.144)	(0.0491)	(0.130)	(0.0764)	0.000	0.00467
Equipment safety index	−1.103***	0.361	1.036*	1.394***	−0.939	**3.862**
	(0.405)	(0.260)	(0.614)	(0.426)	0.920	0.0114
Environment index	1.890***	0.616***	−0.378	0.180	−**0.200**	**0.292**
	(0.247)	(0.169)	(0.502)	(0.160)	0.000	0.000

Continued.

Table 5. *Continued.*

Variables	Worker Perception		Manager Perception		Transmission Index	
	Worker Satisfaction (1)	Worker Well-being (2)	Worker Satisfaction (3)	Worker Well-being (4)	Satisfaction (5)	Well-being (6)
Temporary to permanent worker index	0.0848	0.00587	−0.0368	0.0331	−0.434	5.647
	(0.0972)	(0.0355)	(0.152)	(0.0626)	0.634	0.696
Method of pay index	0.300	−0.0116	0.342	0.114	1.137	−9.859
	(0.388)	(0.241)	(0.303)	(0.118)	0.917	0.935
Male	0.0431	0.0721***	−0.0459	0.0433**		
	(0.0309)	(0.0118)	(0.0409)	(0.0175)		
Education	−0.0102**	−0.00725***	−0.0223***	−0.0108***		
	(0.00487)	(0.00171)	(0.00562)	(0.00194)		
Married	0.0304	0.0370***	0.0368	0.0354**		
	(0.0336)	(0.0126)	(0.0356)	(0.0163)		
Worker health	0.366***	0.0971***	0.528***	0.151***		
	(0.0554)	(0.0235)	(0.0643)	(0.0306)		
Household size	0.0288**	0.00442	0.0234	0.000704		
	(0.0131)	(0.00529)	(0.0142)	(0.00695)		
Age	−0.00657***	0.000962	−0.00235	0.00204		
	(0.00184)	(0.000749)	(0.00288)	(0.00127)		
Constant	0.472	1.467***	1.423**	2.526***		
	(0.408)	(0.283)	(0.641)	(0.425)		
Observations	3,491	3,491	305	305		
R^2	0.172	0.186	0.054	0.074		

CBA = collective bargaining agreement.
Notes: Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.
Source: Authors' calculations.

other workplace hazards would be as important as other aspects of harsh working conditions in determining life satisfaction.

B. Manager Perceptions of Working Conditions

We turn now to consider the impact of manager perceptions of working conditions on worker life satisfaction and well-being. Estimates of the parameters of equation (5) are reported in columns (3) and (4) of Table 5.

A striking feature of the results in Table 5 is that far fewer indices have statistically significant impacts. For worker satisfaction, only pay transparency and the equipment safety index enter as statistically significant (and positive). For worker well-being, equipment safety enters as positive and significant as well and the bonus concern enters negatively. The manager assessments do not pick up the relevance of forced labor, health services, environment, training, and wage concerns. In this sense, managers underappreciate the value of workplace amenities on well-being and satisfaction from the workers' perspective. The managers' assessment of the value of wages is also smaller than workers' own assessment.

C. Formally Comparing Perceptions of Working Conditions

The transmission parameters for a common set of working conditions are reported in columns (5) and (6) of Table 5. For each working condition, the α coefficients from the worker and manager perspectives (estimated separately as described above) are reported along with robust standard errors calculated with the combined variance–covariance matrix from the two separate regressions. The transmission coefficient, g', is then calculated as the quotient of the manager coefficient divided by the worker coefficient. Below each quotient (in parentheses) is the p-value of a chi-square test of the nonlinear hypothesis that the quotient is equal to 1.

In column (5), which focuses on the transmission coefficients where the index is statistically significantly and different from 1, we note that the transmission coefficient is less than 1 in all but one instance. In other words, working conditions typically have a greater impact on worker satisfaction based on worker perceptions rather than those of managers. Likewise, in column (6), three of the five transmission coefficients that are statistically significant and different from 1 are less than 1, and one of the coefficients that is greater than 1 in absolute value is negative, meaning that managers flip the importance of working conditions when compared to the workers' assessment. For example, managers underweight the relevance of the wage and low wage concerns more generally than workers.

However, a similar pattern can be observed for nonmonetary benefits such as health services and the working environment, which enter positive for both

Table 6. **Compliance Cluster Regression Results**

	Satisfied	**Well-being**
Child labor index	1.247	0.602
	(3.32)**	(3.25)**
Compensation index	−1.722	−1.011
	(3.94)**	(4.70)**
Contract and HR index	0.020	−0.133
	(0.08)	(1.08)
Discrimination index	5.764	2.800
	(4.27)**	(4.22)**
Forced labor index	13.538	6.571
	(4.31)**	(4.25)**
Freedom of association index	0.925	0.406
	(1.95)	(1.74)
OSH index	0.054	0.179
	(0.29)	(1.95)
Working time index	0.607	0.516
	(2.33)*	(4.01)**
Factory index	0.132	−0.038
	(1.13)	(0.66)
Male	−0.039	0.065
	(0.81)	(2.80)**
Education	−0.033	−0.020
	(4.80)**	(6.02)**
Married	0.109	0.076
	(2.63)**	(3.72)**
Worker health	0.481	0.121
	(6.44)**	(3.29)**
Household size	0.040	0.022
	(2.33)*	(2.58)*
Age	−0.000	0.003
	(0.07)	(1.84)
Constant	−4.480	0.265
	(2.64)**	(0.32)
R^2	0.07	0.08
N	2,051	2,051

HR = human resource, OSH = occupational safety and health.
Notes: t-statistics in parentheses. $^{*}p < 0.05$; $^{**}p < 0.01$.
Source: Authors' calculations.

satisfaction and well-being from the workers' perspective but are not statistically significant from the managers' perspective. This suggests that there are potential efficiency gains from aligning working conditions with worker values.

D. Compliance Assessments of Working Conditions

Finally, we consider working conditions as measured by Enterprise Assessments and the results are reported in Tables 6 and 7. Two forms of aggregation are used. Compliance averages are calculated for each subcluster. Subclusters were

Table 7. **Compliance Subclusters Regression Results**

	Satisfied	**Well-being**
Child labor index	0.230	0.228
	(0.44)	(0.87)
Method of payment index	5.056	0.861
	(3.48)**	(1.19)
Minimum wage index	−0.725	−0.073
	(2.02)*	(0.41)
Overtime index	−0.143	−0.228
	(0.92)	(2.96)**
Paid leave index	−1.049	−0.340
	(3.19)**	(2.08)*
Premium pay index	0.525	0.061
	(3.06)**	(0.72)
Social security index	−0.283	0.143
	(1.79)	(1.82)
Information index	−0.319	−0.272
	(1.51)	(2.58)**
Contracting procedure index	0.436	0.114
	(2.75)**	(1.44)
Discipline index	−0.621	−0.327
	(3.12)**	(3.31)**
Employment contract index	0.099	−0.176
	(0.51)	(1.81)
Termination index	0.679	0.558
	(0.99)	(1.64)
Gender index	−1.837	−0.839
	(2.94)**	(2.70)**
Other grounds index	−2.208	−2.672
	(1.29)	(3.14)**
Bonded labor index	4.715	2.395
	(5.91)**	(6.04)**
CBA index	−0.258	−0.105
	(0.83)	(0.68)
Strikes index	0.420	0.129
	(0.50)	(0.31)
Union operations index	1.326	0.732
	(4.56)**	(5.07)**
Chemicals index	−0.199	−0.090
	(2.39)*	(2.17)*
Emergency prepare index	−0.111	0.183
	(0.49)	(1.63)
Health services index	0.174	−0.025
	(1.29)	(0.37)
OSH manage index	0.224	0.118
	(1.92)	(2.04)*
Welfare facilities index	0.208	−0.218
	(1.25)	(2.63)**
Accommodation index	−0.932	−0.398
	(0.88)	(0.75)
Work protection index	0.151	0.306
	(0.73)	(2.97)**

Continued.

Table 7. *Continued.*

	Satisfied	**Well-being**
Work environment index	0.139	0.067
	(0.77)	(0.74)
Leave index	−0.502	−0.394
	(0.83)	(1.30)
Overtime working index	0.456	0.504
	(2.66)**	(5.93)**
Regular hours index	−0.580	−0.234
	(1.85)	(1.50)
Factory index	0.147	0.049
	(1.12)	(0.75)
Male	−0.045	0.067
	(0.94)	(2.82)**
Education	−0.036	−0.022
	(5.39)**	(6.72)**
Worker health	0.411	0.109
	(5.52)**	(2.95)**
Household size	0.037	0.023
	(2.27)*	(2.82)**
Age	0.001	0.004
	(0.28)	(3.10)**
Constant	−1.504	3.700
	(0.78)	(3.87)**
R^2	0.11	0.11
N	2,054	2,054

CBA = collective bargaining agreement, OSH = occupational safety and health.
Notes: $^{*}p < 0.05$, $^{**}p < 0.01$.
Source: Authors' calculations.

aggregated into clusters using the Better Work taxonomy, with the results reported in Table 6. Results within the subclusters themselves are reported in Table 7.

Analysis based on the Better Work clusters suggests that Better Work is effectively identifying working conditions that significantly affect worker well-being. Coefficients are positive and statistically significant for child labor (satisfaction 1.247, well-being 0.602), discrimination (satisfaction 5.764, well-being 2.800), forced labor (satisfaction 13.538, well-being 6.571), and work time (satisfaction 0.607, well-being 0.516).

The coefficient estimates for equation (6) are of the same order of magnitude as for equation (4). That is, variations in working conditions as identified by Better Work are similar in magnitude as those detected by workers themselves.

The one compliance point on which Better Work assessments deviate significantly from those of workers is compensation. Improvements in compensation compliance as measured by Better Work are negatively associated with worker outcomes. The compensation coefficient is −1.722 in the satisfaction equation and −1.011 in the well-being equation.

The source of the discrepancy can be understood by examining the results when working conditions are measured by the subclusters as reported in Table 7. Negative coefficients emerge for the minimum wage index (−0.725), paid leave index (−1.049), discipline index (−0.621), gender index (−1.837), and the chemicals index (−0.199).

The negative relationship between some compliance points and global life satisfaction raises questions about factory conditions that Enterprise Assessments are identifying, although it is also possible that Better Work assessments are inducing firms to deviate from the cost-minimizing compensation configuration. Placing equal emphasis on all dimensions of compliance may put Better Work assessments somewhat at odds with worker preferences with regard to working conditions.

V. Conclusion

One possible reason for the persistence of poor working conditions in developing economies is that managers may not be fully aware of the value that workers place on different workplace amenities. Analysis of manager and worker survey data from Better Work Vietnam Monitoring and Evaluation, collected from January 2010 through August 2012, indicates that working conditions have a significant positive impact on global life satisfaction and measures of depression and traumatic stress. This paper offers a simple test of the conjecture that factory managers may not be offering a cost-minimizing configuration of compensation and workplace amenities. The findings reveal significant deviations of manager perceptions of working conditions from those of workers and these deviations significantly impact a worker's perception of well-being and indicators of mental health. Such deviations may lead the factory manager to underprovide certain workplace amenities relative to the cost-minimizing configuration.

In particular, while workers value monetary benefits, they also value nonmonetary amenities such as health services and a safe working environment. Furthermore, the fact that manager perceptions do not align with those of workers suggests that managers are unaware that incremental investments in such nonmonetary benefits would be valued by workers, in addition to incremental monetary rewards.

At the same time, further research will be needed to formulate specific policy proposals. In particular, in order to determine whether the working conditions configuration is cost minimizing, it is necessary to know the marginal cost of each working condition. It would also be valuable to estimate similar hedonic worker satisfaction and well-being models in other labor markets and economies. Finally, our analysis provides a framework for assessing the impact of Better Work on working conditions and the impact that Better Work-induced innovations have on life satisfaction and mental health.

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Appendix

Table A.1. **Worker Indices**

Index	**Components**
Method of pay index*	How often paid, late payment concerns
Annual wage*	Annualized pay, Tet bonus
Wage concern index*	Low wage concerns
Bonus concern index*	Bonuses received, Tet concerns
In-kind compensation and benefits index*	In-kind compensation concerns, benefits received
Pay transparency index*	Info on pay statement, piece rate explanation concerns
Deductions concern index	Deductions made, deduction concerns
Disciplinary concerns index	Workers corrected fairly, verbal abuse concerns, physical abuse concerns
Training index*	Induction training, recent training
Gender discrimination index*	Gender as a barrier to promotion, sexual harassment concerns
Race discrimination index	Ethnicity as a barrier to promotion, nationality as a barrier to promotion
Religion and/or ethnic discrimination index	Religion as a barrier to promotion
Forced labor index*	Punch clock concerns, bathroom denials
CBA index*	Presence of a collective bargaining agreement
Union representative assistance index	Comfort in seeking out a trade union representative
Chemical hazard index*	Hazardous chemical concerns
Health services index*	Presence of a health clinic, health services provided, treatment quality
Food water sanitation index	Drinking water satisfaction, canteen satisfaction, bathroom satisfaction, how often workers drink
Equipment safety index*	Dangerous equipment concerns, accident concerns
Environment index*	Temperature concerns, air quality concerns

Continued.

Table A.1. *Continued.*

Index	Components
Overtime index	Too much overtime concerns
Sunday work concern index	Too much work on Sundays concerns
Temporary to permanent worker index*	Current employees, ratio of temporary to permanent employees, nonproduction employees

CBA = collective bargaining agreement.
Note: *denotes indices common to the worker and manager surveys.
Source: Authors' compilation.

Table A.2. **Manager Indices**

Index	Components
Age verification index	Age verification required on application
Method of pay index*	Late payment concerns
Annual wage*	Annualized pay, Tet bonus
Wage concern index*	Low wage concerns
Bonus concern index*	Tet concerns
In-kind compensation and benefits index*	In-kind compensation concerns, meal allowance, benefits provided
Pay transparency index*	Info on pay statement, piece rate explanation concerns
Training index*	Induction training, time spent training basic skills, recent supervisor training, recent sewer training
Gender discrimination index*	Sexual harassment concerns
Forced labor index*	Punch clock concerns
CBA index*	Presence of collective bargaining agreement, issues dealt with by CBA, presence of worker committee, worker committee effectiveness
Union effectiveness index	Trade union effectiveness
Chemical hazard index*	Hazardous chemicals concerns
Health services index*	Health services provided
Housing index	Housing provided
Equipment safety index*	Dangerous equipment concerns, accident concerns
Environment index*	Temperature concerns, air quality concerns
Temporary to permanent worker index*	Current employees, ratio of temporary to permanent employees, nonproduction employees

CBA = collective bargaining agreement.
Note: *denotes indices common to the worker and manager surveys.
Source: Authors' compilation.

Decomposing Total Factor Productivity Growth in Manufacturing and Services

NEIL FOSTER-MCGREGOR AND BART VERSPAGEN*

Using the World Input–Output Database, this paper calculates total factor productivity (TFP) growth for a sample of 40 economies during the period 1995–2009 to show that TFP growth in Asian economies has been relatively strong. In a number of Asian economies, TFP growth in services has outpaced that in manufacturing. This paper presents a novel structural decomposition of TFP growth and shows that the main drivers of aggregate productivity growth, as well as differences in productivity growth between services and manufacturing, have been changing factor requirements. These effects tend to offset the negative productivity effect of a declining ratio of value added to gross output.

Keywords: manufacturing and services, structural decomposition, total factor productivity
JEL codes: O40, O57

I. Introduction

A great deal of effort has been expended in trying to understand why differences in the dynamics of productivity persist across both economies and time (see, for example, Temple 1999). The reason for such an interest is clear: relatively minor differences in productivity growth between economies, when sustained over time, can lead to large differences in standards of living. One particular strand of this literature highlights and attempts to explain the relatively strong performance of Asian economies in terms of productivity growth in the recent past (see, for example, Young 1992, Krugman 1994, Felipe 1997).

In this paper, we update the discussion of the relative performance of Asian economies vis-à-vis the rest of the world. Using data from the World Input–Output Database (WIOD), the paper confirms the relatively strong performance of Asian economies in terms of total factor productivity (TFP) growth over the period 1995–2009. The paper further shows that while for most economies in the sample, TFP growth in manufacturing has outpaced that of TFP growth in services—which

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is consistent with the view that productivity in services is in general lower than in manufacturing (see, for example, Baumol 1967)—in a number of economies, particularly Asian economies, TFP growth in services has been faster than in manufacturing, lending some support to the concept of an "Asian services model" (Park and Noland 2013).

In search of an explanation for the relatively strong performance of Asian economies and of the different dynamics of productivity in manufacturing and services, this paper presents a novel structural decomposition of TFP growth by building upon the work of Dietzenbacher, Hoen, and Los (2000). Our approach decomposes the growth of TFP into changes in factor requirements, changes in the value-added content of output, and changes in the structure and composition of intermediate and final demand.

The approach adopted is related to recent contributions, such as McMillan, Rodrik, and Verduzco-Gallo (2014) and Timmer, de Vries, and de Vries (2015), who use sectoral-level productivity data to decompose aggregate productivity changes into effects of within-industry changes in productivity and effects of sectoral labor reallocations, with the results tending to suggest that within-sector productivity changes often drive aggregate productivity changes. This paper is also interested in decomposing productivity changes but moves away from the traditional shift-share analysis of McMillan, Rodrik, and Verduzco-Gallo (2014) and Timmer, de Vries, and de Vries (2015). Instead, the current paper builds upon the approach of Chenery, Shishido, and Watanabe (1962); Feldman, McClain, and Palmer (1987); Wolff (1985); and Dietzenbacher, Hoen, and Los (2000) who use structural decomposition methods to decompose productivity growth into the growth of its constituent parts (e.g., value added and labor requirements).[1] Adopting a structural decomposition approach to decompose productivity has a number of advantages, most notably by acknowledging that industries are interdependent (both within and across economies) and through input–output linkages allowing one to capture the productivity effects of these interactions. With the rise of global value chains (GVCs) (see Amador and Cabral [2016] for a recent survey), understanding and identifying the impacts of these input–output relations on productivity growth is a timely and worthwhile exercise.

Using the developed structural decomposition of TFP growth, this paper decomposes overall TFP growth rates as well as differences in TFP growth between the manufacturing and service sectors. The results suggest that declining factor requirements are the main determinant of TFP growth in the sample of WIOD economies, with a declining domestic value-added content of gross output serving to reduce TFP growth in most economies. The role of input–output linkages tends to be limited, though some evidence of a role for the changing structure and composition of intermediate and final goods demand is found in some economies. When considering

[1] See chapter 13 in Miller and Blair (2009) for more details on structural decomposition analysis.

differences in the relative performance of manufacturing and services, declining factor requirements again tend to dominate, though a role for input–output linkages is also evident for a number of economies. In general, the services productivity advantage that is witnessed in many Asian economies has no simple or single explanation, with changing factor requirements and changing input–output structure and composition being either more or less important in different economies.

The remainder of the paper is organized as follows. Section II discusses and describes the data. Section III describes the decomposition methodology. Section IV presents the main results and section V concludes.

II. Data and Descriptive Analysis

Data are drawn from the WIOD (Timmer 2015).[2] The WIOD reports data on socioeconomic accounts, international input–output tables, and bilateral trade across 35 industries and 40 economies (plus the rest of the world) over the period 1995–2009.[3] Data on value added, gross output, and intermediate purchases needed for the decomposition described in the following section are taken from the world input–output tables and are expressed in millions of United States dollars. Two sets of tables are given, one reporting values in current prices and a second reporting values in previous year prices.

We construct TFP growth and undertake the structural decomposition on a year-on-year basis, thus allowing us to consider growth in real TFP ($\hat{g}_t^{\phi}$) as

$$\hat{g}_t^{\phi} = \ln \frac{\phi_t^{t-1}}{\phi_{t-1}^{t-1}} = \ln \frac{v_t^{t-1}}{v_{t-1}^{t-1}} - \overline{\alpha}_t \ln \frac{l_t}{l_{t-1}} - \overline{\beta}_t \ln \frac{k_t}{k_{t-1}}$$

where the superscript refers to the year in which prices are measured; that is, v_t^{t-1} is the value added in period t using previous year $(t-1)$ prices. The factor inputs labor (l) and capital (k) are taken from the socioeconomic accounts and expressed in real terms (hours worked in the case of labor; in 1995 prices and domestic currencies in the case of capital stocks).[4] The labor share (α) is calculated as the share of labor compensation in value added, with the capital share being calculated as the residual ($\beta = 1 - \alpha$). We use a Tornqvist approximation for the labor and capital shares, thus allowing for these shares to be time-varying ($\overline{\alpha}_t = \frac{1}{2}(\alpha_{t-1} + \alpha_t)$ and $\overline{\beta}_t = \frac{1}{2}(\beta_{t-1} + \beta_t)$). Some existing evidence suggests that these shares are not constant over time, with a declining labor share often observed (see, for example, Elsby, Hobijn, and Sahin 2013).

[2]See www.wiod.org for more details.

[3]See Table A.1 in the Appendix for a list of economies and sectors.

[4]We converted the capital stocks from 1995 domestic currencies to United States dollars using the 1995 nominal exchange rates provided in the WIOD.

Our main interest is in considering longer-term changes in TFP (the growth rate between 1995 and 2009), with the growth of real TFP between 1995 and 2009 calculated as

$$\hat{g}^{\phi}_{1995:2009} = \sum_{t=1996}^{2009} \ln \frac{\phi_t^{t-1}}{\phi_{t-1}^{t-1}}$$

Table 1 reports for each of the 40 WIOD economies the initial (1995) level and the cumulative growth rate of TFP over the period 1995–2009, along with unweighted averages for four economy groups: Asia, non-Asian developed, European Union (EU) new member states (NMS), and non-Asian developing. Results are reported for an economy's total TFP and for manufacturing and services TFP separately.[5] The data confirm previous studies and our expectations that TFP growth has been stronger in Asia than in other regions, with cumulative TFP growth of 35.5% in Asia over the period 1995–2009. The TFP growth rate during the review period was also strong in EU NMS at 26.8% and (to a lesser extent) in non-Asian developing economies at 22%, while TFP growth in developed economies was relatively low at 8.8%. These averages hide a great deal of heterogeneity within each group, with TFP growth in the People's Republic of China (PRC) as high as 89%, compared with growth rates of 17.5% for Japan; 15.4% for Taipei,China; and (perhaps most surprisingly) 15.2% for Indonesia.

When considering manufacturing and services separately, we find that TFP growth in manufacturing outpaced TFP growth in services in EU NMS and non-Asian developed economies, with the difference being more than 15 percentage points in the case of non-Asian developed economies and more than 20 percentage points in the case of EU NMS. Such results are consistent with the view of Baumol (1967) that productivity growth in services tends to be lower than in manufacturing. In the cases of Asia and non-Asian developing economies, however, we observe that TFP growth is higher in services than in manufacturing. Again, there is a great deal of heterogeneity within economy groups. For example, in Asia, services TFP growth outstrips manufacturing TFP growth by more than 40 percentage points in India, while TFP growth in manufacturing is more than 55 percentage points higher than services TFP growth in the Republic of Korea.

Even in the PRC and the Republic of Korea, where TFP growth in manufacturing exceeds that in services, the growth rate of TFP in services was still higher than the average rate for the full sample of economies. In all six Asian economies (and three of the four non-Asian developing economies), services TFP growth over the period 1995–2009 was above 15%, with growth of TFP in manufacturing exceeding 15% in just three Asian economies (and two non-Asian

[5]See Table A.2 in the Appendix for details of which individual industries are considered to comprise manufacturing and services.

Table 1. **Descriptive Statistics for Total Factor Productivity Growth**

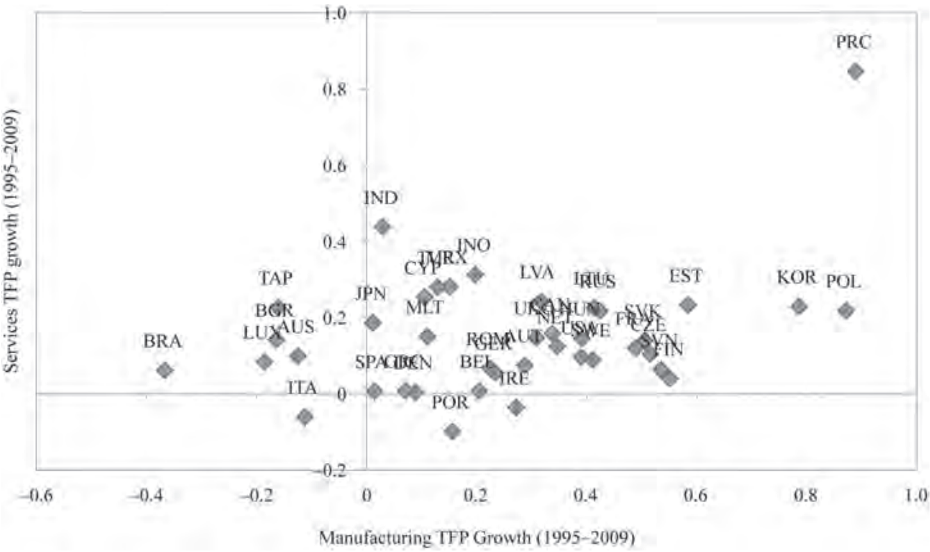
	All Sectors		**Manufacturing**		**Services**	
	ϕ_{1995}	$\hat{g}^{\phi}_{1995:2009}$	ϕ_{1995}	$\hat{g}^{\phi}_{1995:2009}$	ϕ_{1995}	$\hat{g}^{\phi}_{1995:2009}$
Asia		**35.46%**		**29.16%**		**37.33%**
People's Republic of China	0.467	89.03%	0.682	88.85%	0.409	84.65%
Indonesia	0.913	15.24%	1.564	19.72%	0.832	31.33%
India	0.388	32.24%	0.433	2.84%	0.524	43.77%
Japan	5.383	17.45%	6.616	1.08%	5.480	18.63%
Republic of Korea	4.802	43.40%	3.726	78.57%	5.075	22.95%
Taipei,China	4.021	15.41%	3.660	−16.11%	4.190	22.66%
Non-Asian Developed		**8.83%**		**20.73%**		**5.11%**
Australia	4.162	5.31%	6.048	−12.56%	4.291	9.93%
Austria	7.829	14.74%	10.588	28.68%	6.972	7.49%
Belgium	8.914	3.96%	11.721	20.50%	8.555	0.75%
Canada	3.817	16.52%	5.492	33.70%	4.019	15.79%
Germany	8.105	9.19%	17.909	23.32%	6.179	5.52%
Denmark	6.758	1.89%	11.812	8.82%	6.492	0.40%
Spain	4.875	2.82%	6.492	1.40%	4.979	0.66%
Finland	6.493	19.60%	7.608	55.12%	6.493	3.96%
France	5.926	17.94%	10.218	48.84%	5.483	12.02%
United Kingdom	6.061	13.16%	10.007	30.78%	5.877	14.73%
Greece	2.216	3.67%	3.928	7.03%	2.128	0.78%
Ireland	4.869	7.00%	4.451	27.15%	6.215	−3.58%
Italy	5.473	−5.40%	7.411	−11.24%	5.105	−6.05%
Luxembourg	5.122	6.01%	9.334	−18.54%	4.597	8.41%
The Netherlands	7.150	13.95%	9.124	34.57%	7.455	12.42%
Portugal	3.487	−1.59%	3.442	15.55%	3.513	−9.88%
Sweden	6.929	16.98%	7.872	41.09%	6.868	8.94%
United States	5.396	13.13%	7.139	39.00%	5.373	9.66%
EU New Member States		**26.80%**		**36.73%**		**16.55%**
Bulgaria	0.715	7.69%	1.331	−16.40%	0.519	14.19%
Cyprus	3.155	24.49%	4.213	10.55%	3.252	25.34%
Czech Republic	0.810	23.99%	1.168	51.57%	0.724	10.44%
Estonia	1.129	34.14%	1.370	58.32%	1.090	23.30%
Hungary	1.405	30.20%	1.865	39.05%	1.297	14.57%
Lithuania	0.738	29.36%	1.102	41.32%	0.705	22.56%
Latvia	1.039	31.52%	1.319	31.72%	0.942	24.27%
Malta	2.504	12.25%	4.157	11.03%	2.309	15.06%
Poland	4.265	52.30%	2.203	87.05%	1.738	21.83%
Romania	0.899	19.32%	1.127	22.42%	0.700	6.73%
Slovakia	0.757	27.10%	1.120	50.60%	0.663	13.97%
Slovenia	6.183	29.24%	5.766	53.48%	4.589	6.35%
Non-Asian Developing		**22.02%**		**8.38%**		**21.03%**
Brazil	1.149	−0.22%	1.798	−36.72%	1.228	6.16%
Mexico	0.630	28.91%	1.085	15.01%	0.630	28.13%
Russian Federation	1.118	26.62%	1.049	42.35%	1.346	21.80%
Turkey	0.924	32.78%	1.064	12.88%	0.781	28.02%

EU = European Union.

Notes: This table reports the initial (1995) level of total factor productivity (TFP) by economy for (i) all World Input–Output Database sectors, (ii) the manufacturing sector only, and (iii) the service sector only, as well as the (cumulative) growth rate of TFP over the period 1995–2009. TFP growth rates for the four economy groups are unweighted averages.

Source: Authors' calculations using the World Input–Output Database. www.wiod.org

Figure 1. **Scatterplot of Manufacturing and Services Total Factor Productivity Growth, 1995–2009**



AUS = Australia; AUT = Austria; BEL = Belgium; BGR = Bulgaria; BRA = Brazil; CAN = Canada; CYP = Cyprus; CZE = Czech Republic; DEN = Denmark; EST = Estonia; FIN = Finland; FRA = France; GER = Germany; GRC = Greece; HUN = Hungary; IND = India; INO = Indonesia; IRE = Ireland; ITA = Italy; JPN = Japan; KOR = Republic of Korea; LTU = Lithuania; LUX = Luxembourg; LVA = Latvia; MEX = Mexico; MLT = Malta; NET = The Netherlands; POL = Poland; POR = Portugal; PRC = People's Republic of China; ROM = Romania; RUS = Russian Federation; SVK = Slovakia; SVN = Slovenia; SPA = Spain; SWE = Sweden; TAP = Taipei,China; TFP = total factor productivity; TUR = Turkey; UKG = United Kingdom; USA = United States.
Source: Authors' calculations using World Input–Output Database. www.wiod.org

developing economies). This outcome suggests that services production need not imply low overall TFP growth and may further point to the possibility of an "Asian services model" (Park and Noland 2013).

These differences between TFP growth in manufacturing and services can be further observed in Figure 1, which plots TFP growth in manufacturing against that in services for the period 1995–2009. This figure further shows that there is only a weak correlation between services and manufacturing TFP growth. When considering all observations, the correlation coefficient is 0.35. It falls to 0.14 when the major outlier, the PRC, is excluded from the calculation.[6] There are also numerous individual cases where services TFP growth outperforms that of manufacturing. In a number of these cases, the difference partly reflects poor—and often negative—TFP growth in manufacturing (e.g., Australia; Bulgaria; Brazil; India; Italy; Luxembourg; and

[6]A simple regression of manufacturing TFP growth on a constant and services TFP growth results in a coefficient of 0.64 (significant at the 5% level) when the PRC is included and 0.36 (not significant) when the PRC is excluded.

Taipei,China). In other cases—most notably Indonesia and Japan in Asia as well as Cyprus, Malta, Mexico, and Turkey—higher TFP growth rates for services arise despite positive TFP growth rates for manufacturing.

To understand further these differences in TFP growth, both across economies and between manufacturing and services, we now proceed to decompose TFP growth using structural decomposition methods in the following section.

III. Methodology

The decomposition method employed in this paper builds upon that developed by Dietzenbacher, Hoen, and Los (2000) for labor productivity, with the current paper decomposing TFP growth rather than the growth of labor productivity. The decomposition of labor productivity changes undertaken by Dietzenbacher, Hoen, and Los (2000) results in six components: two reflect changing labor productivity levels for each industry in each economy, two reflect changing industry output shares across economies, and two reflect changing trade relationships between economies. In their analysis, Dietzenbacher, Hoen, and Los (2000) show that changes in labor requirements per unit of gross output are the biggest determinant of labor productivity changes for six European economies, with part of this positive impact being offset by the productivity-decreasing effect of a smaller share of value added in gross output.

We begin by defining a number of variables used by Dietzenbacher, Hoen, and Los (2000), where N represents the number of industries per economy (35) and C the number of economies (40 plus the rest of the world):[7]

v: aggregate value added (scalar);

l: aggregate labor inputs (scalar);

π: aggregate labor productivity, v/l (scalar);

$\mathbf{A}$: matrix of input coefficients ($NC \times NC$), with typical element a_{ij}^{rs} denoting the input of product i from economy r per unit of output in industry j in economy s;

$\mathbf{L}$: Leontief inverse ($NC \times NC$), $\mathbf{L} \equiv (\mathbf{I} - \mathbf{A})^{-1}$;

$\mathbf{F}$: matrix of final demands ($NC \times C$), with typical element f_i^{rs} giving the final demand for product i produced in economy r by economy s;

[7]WIOD reports for the rest of the world aggregate all variables that we need for our analysis other than data on labor and capital use and compensation. We therefore include the rest of the world as a 41st economy in our analysis, setting the labor and capital variables to some arbitrary values. Doing this allows us to easily include intermediate and final demand from the rest of the world in our calculations while not affecting the measured values of labor productivity and TFP for our 40 economies of interest.

f: vector with element f_i^r giving the final demand for output of industry i in economy r $(NC \times 1)$; $\mathbf{f} = \mathbf{Fe}$ where **e** is the $C \times 1$ summation vector consisting of ones;

λ: vector with elements λ_i^r giving the use of labor per unit of gross output in industry i in economy r $(NC \times 1)$; and

μ: vector with elements μ_i^r giving the value added per unit of gross output in industry i in economy r $(NC \times 1)$.

In order to extend the analysis to a decomposition of TFP growth, we further define the following additional variables:

k: aggregate capital inputs (scalar),[8]

τ: vector with elements τ_i^r giving the use of capital per unit of gross output in industry i in economy r $(NC \times 1)$,

α: labor share in total compensation of capital and labor (scalar), and

β: capital share in total compensation of capital and labor (scalar).

Given the above definitions we can further define

$$v = \mu'\mathbf{x}$$

$$l = \lambda'\mathbf{Lf} \text{ and}$$

$$k = \tau'\mathbf{Lf}$$

where **x** is the $NC \times 1$ vector of gross output levels x_i^r of industry i in economy r:

$$\mathbf{x} = \mathbf{Ax} + \mathbf{f} = (\mathbf{I} - \mathbf{A})^{-1}\,\mathbf{f} = \mathbf{Lf}$$

To decompose TFP growth, we start with a general form of the production function:

$$v_t = F\,(\phi_t, l_t, k_t)$$

with ϕ being TFP. Taking logs and derivatives with respect to time we get

$$\frac{\dot{v}}{v} = \frac{F_\phi \phi}{v}\frac{\dot{\phi}}{\phi} + \frac{F_l l}{v}\frac{\dot{l}}{l} + \frac{F_k k}{v}\frac{\dot{k}}{k}$$

[8]We assume that capital is a primary factor of production rather than a produced input to production. In his analysis, Wolff (1985) assumes the latter by introducing an additional sector capturing the production of capital goods.

Assuming that technology is Hicks neutral, the growth rate of TFP $g^{\phi} = \frac{F\phi}{v}\frac{\dot{\phi}}{\phi}$ becomes $g^{\phi} = \frac{\dot{\phi}}{\phi}$, while assuming competitive markets implies that factors are paid their social marginal products; that is, $F_k = r$ and $F_l = w$. We can then write

$$g^{\phi} = \frac{\dot{v}}{v} - \frac{wl}{v}\frac{\dot{l}}{l} - \frac{rk}{v}\frac{\dot{k}}{k}$$

The capital and labor shares are written as $\beta = \frac{rk}{v}$ and $\alpha = \frac{wl}{v}$, and under the assumption of constant returns to scale we have $\beta + \alpha = 1$.

Using the discrete time approximation, we then have

$$\hat{g}^{\phi} = \ln\frac{v_t}{v_{t-1}} - \bar{\alpha}_t \ln\frac{l_t}{l_{t-1}} - \bar{\beta}_t \ln\frac{k_t}{k_{t-1}}$$

with

$$\hat{g}^{\phi} = \ln\frac{\phi_t}{\phi_{t-1}}$$

Using $v = \mu'\mathbf{Lf}$, $l = \lambda'\mathbf{Lf}$, and $k = \tau'\mathbf{Lf}$, we can write aggregate TFP growth as

$$\hat{g}^{\phi} = \ln\left(\frac{\mu_1'\mathbf{L_1f_1}}{\mu_0'\mathbf{L_0f_0}}\right) - \bar{\alpha}_t \ln\left(\frac{\lambda_1'\mathbf{L_1f_1}}{\lambda_0'\mathbf{L_0f_0}}\right) - \bar{\beta}_t \ln\left(\frac{\tau_1'\mathbf{L_1f_1}}{\tau_0'\mathbf{L_0f_0}}\right) \tag{1}$$

The first two terms on the right-hand side of equation (1) can be written as

$$\ln\frac{\mu_1'\mathbf{L_1f_1}}{\mu_0'\mathbf{L_1f_1}} + \ln\frac{\mu_0'\mathbf{L_1f_1}}{\mu_0'\mathbf{L_0f_1}} + \ln\frac{\mu_0'\mathbf{L_0f_1}}{\mu_0'\mathbf{L_0f_0}}$$

and

$$\bar{\alpha}_t\ln\frac{\lambda_1'\mathbf{L_1f_1}}{\lambda_0'\mathbf{L_1f_1}} + \bar{\alpha}_t\ln\frac{\lambda_0'\mathbf{L_1f_1}}{\lambda_0'\mathbf{L_0f_1}} + \bar{\alpha}_t\ln\frac{\lambda_0'\mathbf{L_0f_1}}{\lambda_0'\mathbf{L_0f_0}}$$

The third term can be written as

$$\bar{\beta}_t\ln\frac{\tau_1'\mathbf{L_1f_1}}{\tau_0'\mathbf{L_1f_1}} + \bar{\beta}_t\ln\frac{\tau_0'\mathbf{L_1f_1}}{\tau_0'\mathbf{L_0f_1}} + \bar{\beta}_t\ln\frac{\tau_0'\mathbf{L_0f_1}}{\tau_0'\mathbf{L_0f_0}}$$

Combining and rearranging these terms gives

$$\hat{g}^{\phi} = \ln\frac{\mu_1'\mathbf{L_1f_1}}{\mu_0'\mathbf{L_1f_1}} - \bar{\alpha}_t\ln\frac{\lambda_1'\mathbf{L_1f_1}}{\lambda_0'\mathbf{L_1f_1}} - \bar{\beta}_t\ln\frac{\tau_1'\mathbf{L_1f_1}}{\tau_0'\mathbf{L_1f_1}} + \left(\ln\frac{\mu_0'\mathbf{L_1f_1}}{\mu_0'\mathbf{L_0f_1}} - \bar{\alpha}_t\ln\frac{\lambda_0'\mathbf{L_1f_1}}{\lambda_0'\mathbf{L_0f_1}} - \bar{\beta}_t\ln\frac{\tau_0'\mathbf{L_1f_1}}{\tau_0'\mathbf{L_0f_1}}\right) + \left(\ln\frac{\mu_0'\mathbf{L_0f_1}}{\mu_0'\mathbf{L_0f_0}} - \bar{\alpha}_t\ln\frac{\lambda_0'\mathbf{L_0f_1}}{\lambda_0'\mathbf{L_0f_0}} - \bar{\beta}_t\ln\frac{\tau_0'\mathbf{L_0f_1}}{\tau_0'\mathbf{L_0f_0}}\right) \tag{2}$$

Dietzenbacher, Hoen, and Los (2000) note that equation (2) can be further decomposed to incorporate the distinction between the effects of aggregate production structure changes and aggregate final demand changes, and the effects of changing international trade (with respect to both intermediate inputs and final demand deliveries). To achieve this, the following matrices are defined:

$\mathbf{A}^*$: a matrix constructed by stacking C identical $N \times NC$ matrices of aggregate intermediate inputs per unit of gross output by industry and economy ($NC \times NC$ matrix), $\forall r.\ [a^*]_{ij}^{rs} = \sum_{r=1}^{C} a_{ij}^{rs}$;

$\mathbf{T^A}$: a matrix of intermediate trade coefficients, representing the shares of each economy in aggregate inputs by input, industry, and economy ($NC \times NC$ matrix), $[t^A]_{ij}^{rs} = a_{ij}^{rs} / [a^*]_{ij}^{rs}$, and $\sum_r [t^A]_{ij}^{rs} = 1$;

$\mathbf{F}^*$: a matrix constructed by stacking C identical $N \times C$ matrices of final demand for product i in economy s ($NC \times C$ matrix). $\forall r.\ [f^*]_i^{rs} = \sum_{r=1}^{C} f_i^{rs}$l; and

$\mathbf{T^F}$: a matrix of final demand trade coefficients, representing the shares of economy r in aggregate final demand for product i in economy s ($NC \times C$ matrix). $\left[t^F\right]_i^{rs} = f_i^{rs} / [f^*]_i^{rs}$, and $\sum_r \left[t^F\right]_i^{rs} = 1$.

We can then write the Leontief inverse as $\mathbf{L} = \left[\mathbf{I} - \mathbf{A}^* \circ \mathbf{T^A}\right]^{-1}$ and $\mathbf{f} = \left[\mathbf{F}^* \circ \mathbf{T^F}\right]\mathbf{e}$, where $\circ$ denotes the Hadamard product (of elementwise multiplication). Using these, we can decompose TFP growth further as

$$\hat{g}^{\phi} = [\theta_1] - [\theta_2] - [\theta_3] + [\theta_4] + [\theta_5] + [\theta_6] + [\theta_7] \tag{3}$$

with

$$\theta_1 = \ln\frac{\mu_1'\mathbf{L_1f_1}}{\mu_0'\mathbf{L_1f_1}}$$

representing the productivity effects of changes in the value added per unit of gross output by industry;

$$\theta_2 = \bar{\alpha}_t\ln\frac{\lambda_1'\mathbf{L_1f_1}}{\lambda_0'\mathbf{L_1f_1}}$$

representing the productivity effects of changes in labor requirements per unit of gross output by industry;

$$\theta_3 = \bar{\beta}_t \ln \frac{\tau_1' \mathbf{L_1 f_1}}{\tau_0' \mathbf{L_1 f_1}}$$

representing the productivity effects of changes in capital requirements per unit of gross output by industry;

$$\theta_4 = \left[\ln \frac{\mu_0' \left[\mathbf{I} - \left(\mathbf{A}_1^* \circ \mathbf{T}_1^{\mathrm{A}}\right)\right]^{-1} \mathbf{f}_1}{\mu_0' \left[\mathbf{I} - \left(\mathbf{A}_0^* \circ \mathbf{T}_1^{\mathrm{A}}\right)\right]^{-1} \mathbf{f}_1} - \bar{\alpha}_t \ln \frac{\lambda_0' \left[\mathbf{I} - \left(\mathbf{A}_1^* \circ \mathbf{T}_1^{\mathrm{A}}\right)\right]^{-1} \mathbf{f}_1}{\lambda_0' \left[\mathbf{I} - \left(\mathbf{A}_0^* \circ \mathbf{T}_1^{\mathrm{A}}\right)\right]^{-1} \mathbf{f}_1} \right.$$
$$\left. - \bar{\beta}_t \ln \frac{\tau_0' \left[\mathbf{I} - \left(\mathbf{A}_1^* \circ \mathbf{T}_1^{\mathrm{A}}\right)\right]^{-1} \mathbf{f}_1}{\tau_0' \left[\mathbf{I} - \left(\mathbf{A}_0^* \circ \mathbf{T}_1^{\mathrm{A}}\right)\right]^{-1} \mathbf{f}_1} \right]$$

representing the productivity effects of changes in the interindustry structure (e.g., due to technological change, factor substitution, and changing output compositions within industries);

$$\theta_5 = \left[\ln \frac{\mu_0' \left[\mathbf{I} - \left(\mathbf{A}_0^* \circ \mathbf{T}_1^{\mathrm{A}}\right)\right]^{-1} \mathbf{f}_1}{\mu_0' \left[\mathbf{I} - \left(\mathbf{A}_0^* \circ \mathbf{T}_0^{\mathrm{A}}\right)\right]^{-1} \mathbf{f}_1} - \bar{\alpha}_t \ln \frac{\lambda_0' \left[\mathbf{I} - \left(\mathbf{A}_0^* \circ \mathbf{T}_1^{\mathrm{A}}\right)\right]^{-1} \mathbf{f}_1}{\lambda_0' \left[\mathbf{I} - \left(\mathbf{A}_0^* \circ \mathbf{T}_0^{\mathrm{A}}\right)\right]^{-1} \mathbf{f}_1} \right.$$
$$\left. - \bar{\beta}_t \ln \frac{\tau_0' \left[\mathbf{I} - \left(\mathbf{A}_0^* \circ \mathbf{T}_1^{\mathrm{A}}\right)\right]^{-1} \mathbf{f}_1}{\tau_0' \left[\mathbf{I} - \left(\mathbf{A}_0^* \circ \mathbf{T}_0^{\mathrm{A}}\right)\right]^{-1} \mathbf{f}_1} \right]$$

representing the productivity effects of changes in trade structure with respect to commodities and services used as intermediate inputs (e.g., due to changes in sourcing patterns associated with GVCs);

$$\theta_6 = \left[\ln \frac{\mu_0' \mathbf{L_0} \left(\mathbf{F}_1^* \circ \mathbf{T}_1^{\mathbf{F}}\right) \mathbf{e}}{\mu_0' \mathbf{L_0} \left(\mathbf{F}_0^* \circ \mathbf{T}_1^{\mathbf{F}}\right) \mathbf{e}} - \bar{\alpha}_t \ln \frac{\lambda_0' \mathbf{L_0} \left(\mathbf{F}_1^* \circ \mathbf{T}_1^{\mathbf{F}}\right) \mathbf{e}}{\lambda_0' \mathbf{L_0} \left(\mathbf{F}_0^* \circ \mathbf{T}_1^{\mathbf{F}}\right) \mathbf{e}} - \bar{\beta}_t \ln \frac{\tau_0' \mathbf{L_0} \left(\mathbf{F}_1^* \circ \mathbf{T}_1^{\mathbf{F}}\right) \mathbf{e}}{\tau_0' \mathbf{L_0} \left(\mathbf{F}_0^* \circ \mathbf{T}_1^{\mathbf{F}}\right) \mathbf{e}} \right]$$

representing the productivity effects of changes in final demand composition (e.g., due to substitution by consumers, investors, or third economies following relative price changes or changing preference structures); and

$$\theta_7 = \left[\ln \frac{\mu_0' \mathbf{L_0} \left(\mathbf{F}_0^* \circ \mathbf{T}_1^{\mathbf{F}}\right) \mathbf{e}}{\mu_0' \mathbf{L_0} \left(\mathbf{F}_0^* \circ \mathbf{T}_0^{\mathbf{F}}\right) \mathbf{e}} - \bar{\alpha}_t \ln \frac{\lambda_0' \mathbf{L_0} \left(\mathbf{F}_0^* \circ \mathbf{T}_1^{\mathbf{F}}\right) \mathbf{e}}{\lambda_0' \mathbf{L_0} \left(\mathbf{F}_0^* \circ \mathbf{T}_0^{\mathbf{F}}\right) \mathbf{e}} - \bar{\beta}_t \ln \frac{\tau_0' \mathbf{L_0} \left(\mathbf{F}_0^* \circ \mathbf{T}_1^{\mathbf{F}}\right) \mathbf{e}}{\tau_0' \mathbf{L_0} \left(\mathbf{F}_1^* \circ \mathbf{T}_0^{\mathbf{F}}\right) \mathbf{e}} \right]$$

representing the productivity effects of changes in the trade structure as regards commodities and services used for final demand purposes.

Dietzenbacher, Hoen, and Los (2000) note that structural change decompositions are not unique and that the sensitivity of decomposition results can be very large. In the additive case, Dietzenbacher and Los (1998) find that reversing the weights and taking the average of the two types of decompositions generates results that are generally close to the average of all decomposition forms, with the variance of the results being much smaller. We follow Dietzenbacher, Hoen, and Los (2000) and undertake both decompositions, reporting the average of the two decompositions in the analysis below.

The above equations provide estimates of the various partial effects on TFP growth for the entire sample of 41 WIOD economies (including the rest of the world) aggregated across economies and industries. To obtain estimates for single economies (across industries) or single industries (across economies), we replace the vectors μ, λ, and τ with diagonal matrices with the same elements along the main diagonal and zeroes elsewhere, further premultiplying all numerators and denominators with $(1 \times NC)$ aggregation vectors.

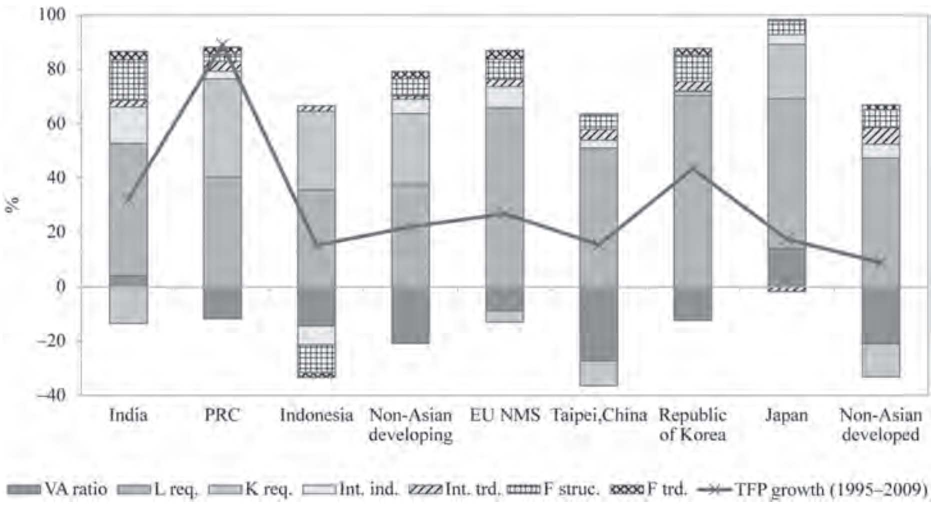
IV. Decomposition of Aggregate Total Factor Productivity Growth

This section reports results for the decomposition of TFP growth using the method described above. We begin by undertaking the decomposition of TFP growth for the aggregate (all 35 WIOD sectors) of each of our economies. Adopting the same approach as discussed in section II, we decompose aggregate real TFP growth by summing up year-on-year real TFP growth and year-on-year real changes in the components of TFP growth, calculated using previous year price data. As such, the Leontief inverse and the final demand vector are calculated in both current and previous year prices. After undertaking the decomposition of aggregate TFP growth, we then undertake the decomposition for manufacturing and services separately, calculating the contributions of the different components to the difference in TFP growth between manufacturing and services. When presenting the results, we report results for the full sample of 40 economies in the Appendix, with results for the six Asian economies and a comparison to (unweighted) average values for the other economy groups (EU NMS, non-Asian developing economies, and non-Asian developed economies) reported in the main text.

Figure 2 reports the results of the TFP decomposition for the six Asian economies and the three economy aggregates, with economies and regions listed in ascending order of initial TFP levels. Table A.3 in the Appendix reports results for the full sample of economies. The line in Figure 2 represents the growth rate of TFP between 1995 and 2009, while the bars decompose TFP growth into its constituent parts.[9] As we have already seen in section II, the growth rate of TFP between 1995

[9]Since some elements of the decompositions are negative (they work against the direction of the change in TFP), only the absolute value of the sum of the different terms equals 100%.

Figure 2. **Structural Decomposition of Total Factor Productivity Growth, 1995–2009**



EU NMS = European Union new member states, F struc. = final demand structure, F trd. = final demand composition, Int. ind. = intermediate input structure, Int. trd. = intermediate input composition, K req. = capital requirements, L req. = labor requirements, PRC = People's Republic of China, TFP = total factor productivity, VA ratio = value-added ratio.
Source: Authors' calculations.

and 2009 was found to be highest for the PRC at about 89%. The TFP growth rate was also above the sample average in India at about 32% and it exceeded the average in Indonesia and the Republic of Korea as well. In Japan and Taipei,China, TFP growth was lower than the sample average.

In terms of the decomposition, we observe positive values for the contribution of the growth of labor requirements for all economies, with the values being relatively large for all Asian economies except Japan and (to a lesser extent) Indonesia. These values were particularly large for the PRC. The values for this component tend to be large relative to the contributions of most other components, including capital requirements, which suggest that labor-saving process innovation and the substitution of direct labor played an important role in enhancing TFP in most economies, particularly in Asia. In the case of Asian economies, we find that the decline in labor input per unit of gross output would have increased TFP by between a low of 9 percentage points in Japan to a high of 47 percentage points in the PRC, assuming that no other factors changed. Relatively large effects of changes in labor requirements were also found for the Republic of Korea (43 percentage points) and Taipei,China (29 percentage points), which is perhaps surprising given its relatively poor TFP growth during the review period. Such outcomes are consistent with the results of Dietzenbacher, Hoen, and Los (2000) for European economies, who also found in their decomposition of labor productivity that the factor with the largest positive impact was the change in labor input per unit of gross output.

Also consistent with the results of Dietzenbacher, Hoen, and Los (2000) is the result that a smaller share of value added in gross output tends to have a productivity-decreasing effect. A potential explanation for such a development relates to the increasing role of GVCs in production that have led to more intermediate deliveries across borders, raising the intermediate content (and lowering the value added) of local gross production. However, there are a number of exceptions to this general conclusion as 11 economies in the full sample reported positive contributions from the change in value added to gross output, including a number of EU transition economies (e.g., Estonia, Latvia, Lithuania, Slovakia, Slovenia) as well as both Japan and India. In the case of Asian economies, the results suggest that the decline in value added to gross output would have decreased TFP by about 14 percentage points in the PRC had no other factors changed, with declines of about 15 percentage points observed for Taipei,China and about 7 percentage points for both Indonesia and the Republic of Korea. Even these smaller numbers for Indonesia and the Republic of Korea tend to be large relative to the other economy groups: declines of 5.4 percentage points, 3.1 percentage points, and 7.8 percentage points, respectively, were observed for non-Asian developed economies, EU NMS, and non-Asian developing economies.

The effects of changes in capital inputs per unit of gross output are mixed across economies, with declines in capital inputs per unit of gross output found to have lowered TFP in 22 economies and increased it in 18 economies. Among all economies, positive effects were the largest in the PRC (42 percentage points) by a wide margin. In Asia, the effects of declining capital usage per unit of gross output were also positive in Indonesia (13 percentage points), Japan (4 percentage points), and the Republic of Korea (1 percentage point), but had a negative impact in India (6 percentage points) and Taipei,China (5 percentage points).

In terms of the remaining four factors, our findings are again consistent with Dietzenbacher, Hoen, and Los (2000) in that there is little evidence of a large productivity growth effect in most economies. However, intermediate composition and intermediate trade structure play an important role in enhancing TFP growth in a number of economies, most notably in non-Asian developed economies, EU NMS, and India. Such results suggest that by changing their sourcing patterns and intermediate trade structure, these economies were able to increase TFP growth, a finding that may be related to the expanding role of GVCs and the increased fragmentation of production. In the case of India, the composition of intermediates is the stronger of the two effects, while for EU NMS and non-Asian developed economies the intermediate trade structure plays the more dominant role. This would suggest that among these two groups a realignment of economy sourcing patterns rather than shifts in intermediate composition due to technological change is the more important source of TFP growth.

Final demand composition and trade structure are also found to make a relatively large contribution to TFP growth for India, EU NMS, and non-Asian developed economies, with the final demand trade structure dominating the two effects. Final demand composition and trade structure together account for more than 10% of overall TFP growth in all other economies except the PRC, Indonesia, and Japan. In the case of Indonesia, the effects of final demand trade structure as well as the trade structure of intermediate demand are found to be negative.

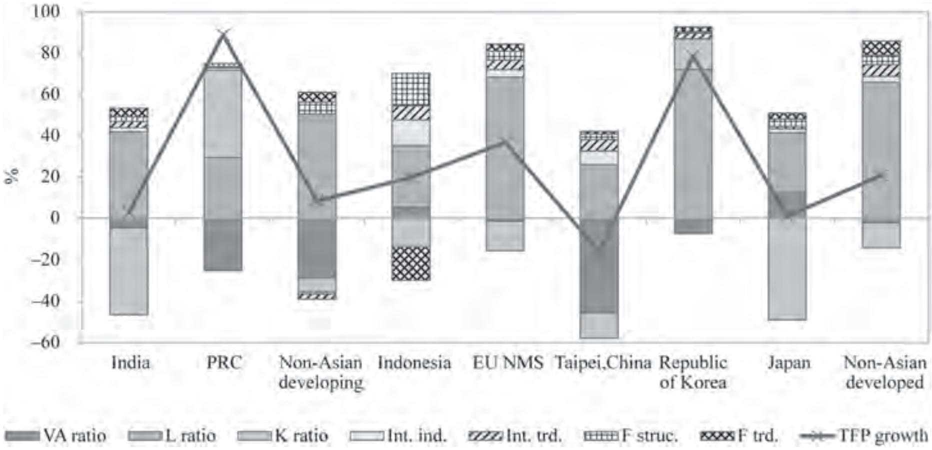
Overall, the results suggest that declining labor and capital requirements per unit of gross output are the main contributors to TFP growth, more than offsetting the negative effect of a smaller share of value added in gross output. The more successful Asian economies during the period tended to minimize their decline in the share of value added in gross output while significantly reducing the labor and capital requirements per unit of gross output. At the same time, there appears to be no single recipe for success, with the PRC benefiting significantly from a drop in capital requirements per unit of gross output, the Republic of Korea benefiting almost exclusively from a drop in labor requirements per unit of gross output, and India benefitting significantly from changes in the structure of intermediate and final demand.

We now turn to the discussion of the structural decomposition of TFP growth for manufacturing and services, examining whether the decomposition can shed any light on the differences in the evolution of TFP in manufacturing and services across economies. In Tables A.4 and A.5 in the Appendix, we report the full decomposition for all 40 economies for both manufacturing and services. In the main text, we concentrate on the comparison between the sample of Asian economies and the other three economy groups, reporting the decomposition of manufacturing and services TFP growth in Figures 3 and 4, respectively, and the results of the decomposition of the difference in the (cumulative) growth rate of TFP for manufacturing and services in Figure 5.[10]

Figures 3 and 4 reveal that declines in the ratio of labor and (to a lesser extent) capital requirements tend to explain the largest part of TFP growth in both manufacturing and services. While the importance of labor requirements is fairly consistent across economies and economy groups, the results for capital requirements are mixed. A declining ratio of capital to gross output spurred TFP growth in both manufacturing and services in the PRC; in manufacturing in the Republic of Korea; and in services in Indonesia, Japan, and non-Asian developing economies. In the case of manufacturing, however, an increasing ratio of capital to gross output negatively impacted TFP growth in many economies, most notably India; Indonesia; Japan; and Taipei,China. Reductions in TFP growth in services due to increasing ratios of capital to gross output are observed for Taipei,China and non-Asian developed economies.

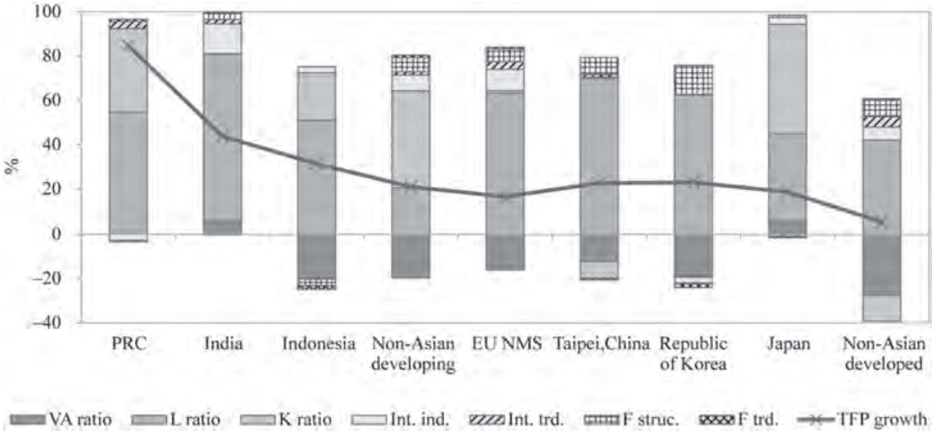
[10]These contributions are calculated simply as the difference in the values of the contributions to manufacturing and services TFP growth.

Figure 3. **Structural Decomposition of Manufacturing Total Factor Productivity Growth, 1995–2009**



EU NMS = European Union new member states, F struc. = final demand structure, F trd. = final demand composition, Int. ind. = intermediate input structure, Int. trd. = intermediate input composition, K ratio = capital ratio, L ratio = labor ratio, PRC = People's Republic of China, TFP = total factor productivity, VA ratio = value-added ratio.
Source: Authors' calculations.

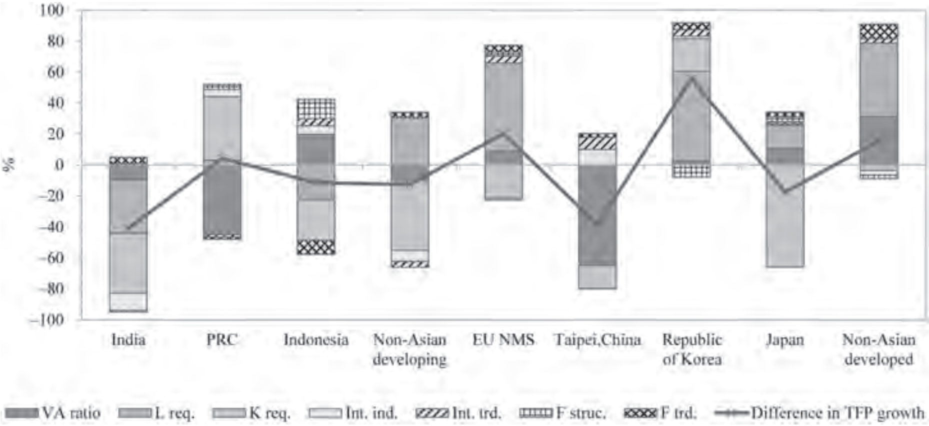
Figure 4. **Structural Decomposition of Services Total Factor Productivity Growth, 1995–2009**



EU NMS = European Union new member states, F struc. = final demand structure, F trd. = final demand composition, Int. ind. = intermediate input structure, Int. trd. = intermediate input composition, K ratio = capital ratio, L ratio = labor ratio, PRC = People's Republic of China, TFP = total factor productivity, VA ratio = value-added ratio.
Source: Authors' calculations.

The results in Figures 3 and 4 further show that changes in intermediate and final demand structure and trade play an important role in some economies. Changes in intermediate and final demand structure account for a relatively large

Figure 5. **Structural Decomposition of Differences in Manufacturing and Services Total Factor Productivity Growth, 1995–2009**



EU NMS = European Union new member states, F struc. = final demand structure, F trd. = final demand composition, Int. ind. = intermediate input structure, Int. trd. = intermediate input composition, K req. = capital requirements, L req. = labor requirements, PRC = People's Republic of China, TFP = total factor productivity, VA ratio = value-added ratio.
Source: Authors' calculations.

proportion of the TFP growth in manufacturing in Indonesia. These two terms are also relatively important for services TFP growth in India; the Republic of Korea; and Taipei,China; as well as in non-Asian developed economies and non-Asian developing economies.

Given the discussion in section II, an explanation is desired for the varying performance of manufacturing and services TFP growth across economies, including whether there is a single explanation for the relatively faster growth of TFP for services in many Asian economies. Figure 5 plots the difference in growth between manufacturing and services (solid line) for select economies and economy groups, with a negative value indicating that TFP grew faster in services than in manufacturing. While in many cases, the difference in TFP growth between manufacturing and services during the review period was relatively small, in other cases, the differences were large. For example, TFP growth in manufacturing exceeded that in services by more than 50 percentage points in the Republic of Korea, while TFP growth in services exceeded that in manufacturing by about 40 percentage points in India and Taipei,China.

Figure 5 reports the contributions of the different decomposition terms to the difference in TFP growth between manufacturing and services. For most economies, the majority of the difference in TFP growth between manufacturing and services is due to differences in the ratios of labor and capital to gross output, highlighting the role of capital requirements. There are some exceptions, however, with Japan being an interesting example. The decline in capital requirements in Japan was strong in services, explaining all of the difference in TFP growth between manufacturing and services; but the decline in labor requirements favored the manufacturing sector, thus dampening the difference between TFP growth in services and manufacturing. A similar outcome was found for non-Asian developing economies, while TFP growth was higher in manufacturing in EU NMS. Declines in the ratio of value added to gross output tended to be larger in the sector that performed relatively poorly, which can also help explain differences in TFP growth between manufacturing and services. There are exceptions, however, with the changes in value added to gross output dampening the productivity advantage of manufacturing in the PRC and the productivity advantage of services in Indonesia and Japan. While smaller, there is also a significant effect from structural change (changing structure of intermediate and final demand) for many economies, with changes in intermediate trade patterns also being relevant for a number of economies, most notably India; Indonesia; and Taipei,China.

Considering the economies in which we observe a higher TFP growth rate in services, there is no pattern that clearly stands out in terms of the factors driving the services advantage. Among Asian economies, India stands out in terms of its high contribution of the structure of intermediates to the services advantage, suggesting that structural change has been relatively important there. This term also plays a relatively important role in the case of non-Asian developing economies. In the cases of Taipei,China and Indonesia, the structure of intermediates also plays an important role by dampening the differences in TFP growth between services and manufacturing. In Indonesia, final demand trade is an important contributor to the TFP growth advantage of services relative to manufacturing, with the structure of intermediates and the structure of final demand and intermediate trade dampening this advantage. Taipei,China represents another interesting example, with relatively strong declines in the ratio of capital to gross output in services and in the ratio of value added to gross output in manufacturing explaining the TFP growth advantage for services. The relatively strong decline in value added in gross output for manufacturing in Taipei,China can be contrasted with the relatively strong decline in value added to gross output for services in the PRC. In Japan, changes in all factors other than the ratio of capital to gross output favor the manufacturing sector, emphasizing the relatively strong decline in the ratio of capital to gross output in services that enabled services TFP growth to be higher than manufacturing TFP growth during the review period.

V. Conclusion

This paper examined differences in TFP growth among a sample of 40 economies, including six Asian economies, and further distinguished between TFP growth in the manufacturing and service sectors. Over the period 1995–2009, Asian economies tended to perform relatively well in terms of TFP growth, partially reflecting a convergence in TFP levels. Consistent with existing evidence, TFP growth in manufacturing tended to outpace that in services for most economies. There are exceptions, however, particularly among Asian economies, suggesting that productivity growth in services need not always be lower than that in manufacturing.

To shed light on these productivity growth differentials across economies and between manufacturing and services, this paper introduced a novel structural decomposition of TFP growth into effects due to changes in factor requirements per unit of gross output, changes in value added per unit of gross output, and changes in the structure and composition of intermediate and final goods. The results suggest that, for most economies, declines in factor requirements—labor in particular—per unit of gross output can explain a large proportion of TFP growth over the period 1995–2009. Furthermore, declines in factor usage offset the negative contribution to TFP growth of a declining ratio of value added to gross output. Changes in the structure and composition of intermediate and final goods tended to contribute less to TFP growth, though they remain important for some economies, particularly changes in the structure of intermediate and final goods, which may partly reflect the role of GVCs in changing sourcing patterns.

The relatively strong performance of services in Asian economies during the review period does not appear to have a single explanation in terms of our decomposition calculations, which show interesting differences among Asian economies. While factor requirements, particularly capital requirements, per unit of gross output remain important for most economies, changes in the structure of intermediates and in final demand composition are also important factors for some economies in explaining the services advantage.

Our findings suggest that although factors such as trade, structural change, and demand dynamics can play a significant role in some economies, they are not the factors that have driven the rise of the service sector in Asia. Rather, changing labor requirements have driven productivity growth in services in Asia. Thus, the idea of services as a traditional sector in which (labor) productivity cannot grow at high rates is subject to revision, particularly with regard to Asia.

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*ADB recognizes “Hong Kong” as Hong Kong, China.

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Appendix

Table A.1. **List of Economies**

Code	Economy	Region
PRC	People's Republic of China	Asia
TAP	Taipei,China	
IND	India	
INO	Indonesia	
JPN	Japan	
KOR	Republic of Korea	
AUT	Austria	EU15
BEL	Belgium	
DEN	Denmark	
FIN	Finland	
FRA	France	
GER	Germany	
GRC	Greece	
IRE	Ireland	
ITA	Italy	
LUX	Luxembourg	
NET	The Netherlands	
POR	Portugal	
SPA	Spain	
SWE	Sweden	
UKG	United Kingdom	
BGR	Bulgaria	EU12
CYP	Cyprus	
CZE	Czech Republic	
EST	Estonia	
HUN	Hungary	
LVA	Latvia	
LTU	Lithuania	
MLT	Malta	
POL	Poland	
ROU	Romania	
SVK	Slovakia	
SVN	Slovenia	
BRA	Brazil	Americas
CAN	Canada	
MEX	Mexico	
USA	United States	
AUS	Australia	Other
RUS	Russian Federation	
TUR	Turkey	

EU = European Union.
Source: World Input–Output Database. www.wiod.org

Table A.2. **Industries and Industry Classification**

Code	Industry	Sector
AtB	Agriculture, Hunting, Forestry, and Fishing	Primary
C	Mining and Quarrying	
15t16	Food, Beverages, and Tobacco	Manufacturing
17t18	Textiles and Textile Products	
19	Leather, Leather and Footwear	
20	Wood and Products of Wood and Cork	
21t22	Pulp, Paper, and Printing and Publishing	
23	Coke, Refined Petroleum, and Nuclear Fuel	
24	Chemicals and Chemical Products	
25	Rubber and Plastics	
26	Other Non-Metallic Mineral	
27t28	Basic Metals and Fabricated Metal	
29	Machinery, not elsewhere classified	
30t33	Electrical and Optical Equipment	
34t35	Transport Equipment	
36t37	Manufacturing, not elsewhere classified; Recycling	
E	Electricity, Gas, and Water Supply	Services
F	Construction	
50	Sale, Maintenance, and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	
51	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	
52	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	
H	Hotels and Restaurants	
60	Inland Transport	
61	Water Transport	
62	Air Transport	
63	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	
64	Post and Telecommunications	
J	Financial Intermediation	
70	Real Estate Activities	
71t74	Renting of Machinery and Equipment and Other Business Activities	
L	Public Administration and Defense; Compulsory Social Security	
M	Education	
N	Health and Social Work	
O	Other Community, Social and Personal Services	
P	Private Households with Employed Persons	

Source: World Input–Output Database. www.wiod.org

Table A.3. **Total Factor Productivity Growth Decomposition, 1995–2009**

			Due to changes in						
Economy	ϕ_{1995}	$\hat{g}^{\phi}$	θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7
Asia									
People's Republic of China	0.467	0.890	−0.137	0.471	0.419	0.033	0.044	0.029	0.032
Taipei,China	4.021	0.154	−0.154	0.288	−0.051	0.017	0.022	0.031	0.001
India	0.388	0.322	0.018	0.214	−0.059	0.059	0.011	0.065	0.014
Indonesia	0.913	0.152	−0.066	0.163	0.132	−0.031	0.010	−0.047	−0.008
Japan	5.383	0.175	0.025	0.100	0.036	0.006	−0.003	0.009	0.001
Republic of Korea	4.802	0.434	−0.071	0.405	0.008	0.001	0.019	0.057	0.014
Non-Asian Developed									
Australia	4.1621	0.0531	−0.0043	0.0782	−0.0370	0.0163	−0.0056	0.0040	0.0014
Austria	7.8286	0.1474	−0.0828	0.1541	0.0141	0.0116	0.0150	0.0321	0.0033
Belgium	8.9137	0.0396	−0.0517	0.1038	−0.0452	0.0058	−0.0022	0.0276	0.0015
Canada	3.8174	0.1652	−0.0461	0.1940	−0.0124	0.0029	0.0146	0.0110	0.0012
Denmark	6.7582	0.0189	−0.1026	0.1081	−0.0203	0.0067	0.0038	0.0228	0.0004
Finland	6.4933	0.1960	−0.0435	0.1699	0.0110	0.0014	0.0255	0.0261	0.0055
France	5.9256	0.1794	−0.0232	0.1521	0.0250	0.0170	0.0025	0.0026	0.0034
Germany	8.1046	0.0919	−0.0442	0.1223	−0.0162	0.0049	−0.0002	0.0277	−0.0023
Greece	2.2155	0.0367	0.0308	0.0871	−0.1452	0.0384	0.0148	0.0119	−0.0012
Ireland	4.8688	0.0700	−0.1150	0.1333	−0.0783	0.0230	0.1177	−0.0722	0.0616
Italy	5.4731	−0.0540	−0.0870	0.0476	0.0045	−0.0266	0.0060	−0.0003	0.0016
Luxembourg	5.1222	0.0601	−0.2815	0.0626	0.0797	0.0348	0.0956	0.0581	0.0108
The Netherlands	7.1505	0.1395	−0.0047	0.1289	−0.0081	0.0057	0.0004	0.0195	−0.0022
Portugal	3.4868	−0.0159	−0.0263	0.0628	−0.1363	0.0317	0.0013	0.0430	0.0081
Spain	4.8753	0.0282	−0.0641	0.0959	−0.0386	0.0141	−0.0014	0.0220	0.0004
Sweden	6.9286	0.1698	0.0217	0.1554	−0.0562	0.0045	0.0092	0.0290	0.0063
United Kingdom	6.0607	0.1316	−0.0718	0.2190	−0.0439	0.0249	−0.0102	0.0238	−0.0102
United States	5.3957	0.1313	0.0164	0.1516	−0.0721	0.0217	−0.0023	0.0171	−0.0012

Continued.

Table A.3. *Continued.*

			Due to changes in						
Economy	$\boldsymbol{\phi_{1995}}$	$\boldsymbol{\hat{g}^{\phi}}$	$\boldsymbol{\theta_1}$	$\boldsymbol{\theta_2}$	$\boldsymbol{\theta_3}$	$\boldsymbol{\theta_4}$	$\boldsymbol{\theta_5}$	$\boldsymbol{\theta_6}$	$\boldsymbol{\theta_7}$
European Union New Member States									
Bulgaria	0.7151	0.0769	−0.1387	0.1376	0.0301	0.0261	−0.0304	0.0422	0.0099
Cyprus	3.1554	0.2449	−0.1360	0.1441	0.1465	0.0329	0.0260	0.0073	0.0242
Czech Republic	0.8095	0.2399	−0.1433	0.2927	0.0376	0.0185	0.0086	0.0099	0.0160
Estonia	1.1291	0.3414	0.0959	0.3010	−0.1815	0.0511	0.0266	0.0463	0.0021
Hungary	1.4047	0.3020	−0.0367	0.2055	0.0597	0.0013	0.0033	0.0306	0.0383
Latvia	1.0395	0.3152	0.0799	0.2874	−0.0851	−0.0028	0.0272	0.0067	0.0047
Lithuania	0.7382	0.2936	0.1278	0.1691	−0.0495	0.0293	0.0210	−0.0132	0.0092
Malta	2.5036	0.1225	−0.0885	0.1863	0.0399	0.0277	0.0005	−0.0244	−0.0191
Poland	4.2647	0.5230	−0.0511	0.4125	0.0561	0.0570	0.0086	0.0352	0.0047
Romania	0.8988	0.1932	−0.1873	0.2875	−0.0052	0.0378	−0.0001	0.0572	0.0033
Slovakia	0.7569	0.2710	0.0844	0.2011	−0.1819	0.0228	0.0266	0.0859	0.0321
Slovenia	6.1826	0.2924	0.0157	0.2424	−0.0531	0.0297	0.0008	0.0408	0.0161
Non-Asian Developing									
Brazil	1.1488	−0.0022	0.0126	0.0562	−0.0741	0.0094	−0.0123	0.0082	−0.0022
Mexico	0.6300	0.2891	−0.0513	0.0041	0.2796	0.0116	0.0089	0.0340	0.0023
Russian Federation	1.1176	0.2662	−0.1233	0.2548	0.0606	0.0227	0.0085	0.0112	0.0318
Turkey	0.9241	0.3278	−0.1515	0.2551	0.1241	0.0359	0.0132	0.0424	0.0086

Note: The figures for the different decompositions are the averages of the original and alternative decomposition.
Source: Authors' calculations.

Table A.4. **Total Factor Productivity Growth Decomposition for Manufacturing, 1995–2009**

			Due to changes in						
Economy	ϕ_{1995}	$\hat{g}^{\phi}$	θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7
Asia									
People's Republic of China	0.6819	0.8885	−0.4410	0.5227	0.7533	0.0199	0.0113	0.0269	−0.0046
Taipei,China	3.6599	−0.1611	−0.4669	0.2669	−0.1263	0.0666	0.0569	0.0293	0.0124
India	0.4328	0.0284	−0.0195	0.1750	−0.1753	0.0083	0.0127	0.0094	0.0177
Indonesia	1.5638	0.1972	0.0261	0.1467	−0.0663	0.0599	0.0337	0.0763	−0.0792
Japan	6.6165	0.0108	0.0683	0.1606	−0.2708	0.0105	0.0064	0.0197	0.0161
Republic of Korea	3.7263	0.7857	−0.0654	0.6603	0.1364	0.0002	0.0255	0.0064	0.0222
Non-Asian Developed									
Australia	6.0484	−0.1256	0.0029	0.1063	−0.2778	0.0296	−0.0075	0.0085	0.0124
Austria	10.5885	0.2868	−0.0874	0.2698	0.0769	0.0072	−0.0038	0.0193	0.0049
Belgium	11.7211	0.2050	0.0082	0.2063	−0.0499	0.0036	0.0123	0.0104	0.0139
Canada	5.4917	0.3370	−0.0745	0.2620	0.1364	0.0082	−0.0007	0.0040	0.0016
Denmark	11.8119	0.0882	−0.0576	0.1739	−0.0804	0.0043	0.0132	0.0127	0.0221
Finland	7.6082	0.5512	0.1438	0.2124	0.0320	0.0433	0.0591	0.0292	0.0313
France	10.2178	0.4884	−0.2497	0.5577	0.1346	0.0056	0.0109	0.0170	0.0123
Germany	17.9087	0.2332	−0.1023	0.2933	0.0010	0.0122	−0.0017	0.0303	0.0004
Greece	3.9284	0.0703	0.1676	−0.0338	−0.1018	−0.0015	0.0156	0.0237	0.0005
Ireland	4.4514	0.2715	−0.1803	0.2188	0.0071	−0.0061	0.1237	−0.0066	0.1148
Italy	7.4108	−0.1124	−0.0977	0.0634	−0.0793	−0.0010	−0.0037	0.0049	0.0010
Luxembourg	9.3344	−0.1854	−0.1323	−0.0710	−0.0309	−0.0003	0.0084	−0.0048	0.0454
The Netherlands	9.1235	0.1555	0.0342	0.1535	−0.1143	0.0057	0.0169	0.0234	0.0361
Portugal	3.4419	0.3457	0.1371	0.1672	0.0103	0.0023	0.0116	0.0079	0.0092
Spain	6.4917	0.0140	−0.1467	0.1646	−0.0380	0.0039	0.0033	0.0144	0.0124
Sweden	7.8720	0.4109	0.2108	0.2038	−0.1056	0.0188	0.0308	0.0248	0.0274
United Kingdom	10.0075	0.3078	0.0920	0.2609	−0.0485	−0.0023	0.0030	0.0007	0.0020
United States	7.1393	0.3900	0.2247	0.2089	−0.0930	0.0183	0.0028	0.0164	0.0120

Continued.

Table A.4. *Continued.*

			Due to changes in						
Economy	$\boldsymbol{\phi_{1995}}$	$\hat{g}^{\phi}$	θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7
European Union New Member States									
Bulgaria	1.3308	−0.1640	−0.1778	0.0871	−0.1473	0.0573	0.0193	0.0307	−0.0334
Cyprus	4.2131	0.1055	−0.1429	0.1270	0.0007	0.0434	0.0043	0.0147	0.0583
Czech Republic	1.1684	0.5157	−0.0273	0.4615	0.0344	0.0054	0.0179	0.0118	0.0119
Estonia	1.3701	0.5832	0.0708	0.5982	−0.1985	0.0235	0.0387	0.0489	0.0015
Hungary	1.8649	0.3905	−0.0618	0.2568	−0.0798	0.0391	0.0569	0.0688	0.1105
Latvia	1.3189	0.3172	0.1029	0.4245	−0.2411	−0.0003	0.0249	0.0089	−0.0026
Lithuania	1.1018	0.4132	0.1512	0.4045	−0.2244	0.0019	0.0357	0.0123	0.0320
Malta	4.1571	0.1103	0.2359	0.1129	−0.2093	−0.0062	0.0357	−0.0580	−0.0006
Poland	2.2029	0.8705	−0.1086	0.7175	0.2036	0.0244	0.0064	0.0295	−0.0023
Romania	1.1270	0.2242	−0.1383	0.3295	−0.0467	0.0211	0.0032	0.0713	−0.0158
Slovakia	1.1204	0.5060	−0.0705	0.4122	0.0426	0.0237	0.0485	0.0187	0.0308
Slovenia	5.7655	0.5348	0.0739	0.4334	−0.0317	−0.0014	0.0099	0.0209	0.0299
Non-Asian Developing									
Brazil	1.7980	−0.3672	0.2195	−0.0654	−0.5347	0.0113	−0.0203	0.0295	−0.0071
Mexico	1.0849	0.1501	−0.1517	0.0888	0.1653	0.0064	0.0028	0.0282	0.0103
Russian Federation	1.0494	0.4235	−0.0463	0.3664	0.0257	0.0002	0.0071	−0.0305	0.1010
Turkey	1.0638	0.1288	−0.4546	0.3743	0.2415	−0.0309	−0.0298	0.0618	−0.0335

Note: The figures for the different decompositions are the averages of the original and alternative decomposition.
Source: Authors' calculations.

Table A.5. **Total Factor Productivity Growth Decomposition for Services, 1995–2009**

			Due to changes in						
Economy	ϕ_{1995}	$\hat{g}^{\phi}$	θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7
Asia									
People's Republic of China	0.4088	0.8465	0.0020	0.4933	0.3436	−0.0246	0.0299	−0.0064	0.0087
Taipei,China	4.1901	0.2266	−0.0475	0.2697	−0.0289	0.0019	0.0050	0.0297	−0.0033
India	0.5239	0.4377	0.0234	0.3326	0.0010	0.0589	0.0086	0.0144	−0.0011
Indonesia	0.8318	0.3133	−0.1244	0.3162	0.1333	0.0174	−0.0012	−0.0185	−0.0096
Japan	5.4801	0.1863	0.0103	0.0759	0.0951	0.0057	−0.0017	0.0021	−0.0012
Republic of Korea	5.0751	0.2295	−0.0833	0.2768	−0.0024	−0.0116	−0.0016	0.0597	−0.0081
Non-Asian Developed									
Australia	4.2907	0.0993	−0.0073	0.0721	0.0127	0.0136	0.0003	0.0070	0.0010
Austria	6.9717	0.0749	−0.0854	0.1084	0.0094	0.0103	0.0115	0.0197	0.0009
Belgium	8.5545	0.0075	−0.0683	0.0849	−0.0452	0.0084	−0.0019	0.0285	0.0009
Canada	4.0187	0.1579	−0.0362	0.1938	−0.0222	0.0072	0.0030	0.0119	0.0005
Denmark	6.4917	0.0040	−0.1159	0.0898	−0.0128	0.0155	0.0014	0.0268	−0.0008
Finland	6.4934	0.0396	−0.1216	0.1356	0.0126	0.0004	0.0029	0.0092	0.0006
France	5.4831	0.1202	0.0169	0.0731	0.0146	0.0174	0.0004	−0.0039	0.0017
Germany	6.1790	0.0552	−0.0293	0.0725	−0.0205	0.0076	0.0038	0.0201	0.0011
Greece	2.1278	0.0078	0.0089	0.0997	−0.1470	0.0259	0.0098	0.0101	0.0004
Ireland	6.2150	−0.0358	−0.0845	0.0711	−0.0698	0.0151	0.0551	−0.0389	0.0161
Italy	5.1054	−0.0605	−0.0886	0.0309	0.0252	−0.0394	0.0118	−0.0051	0.0047
Luxembourg	4.5966	0.0841	−0.3011	0.0716	0.1032	0.0374	0.1038	0.0623	0.0069
The Netherlands	7.4554	0.1242	−0.0294	0.1235	−0.0084	0.0127	−0.0012	0.0271	−0.0001
Portugal	3.5133	−0.0988	−0.0302	0.0074	−0.1560	0.0347	−0.0023	0.0478	−0.0001
Spain	4.9791	0.0066	−0.0453	0.0557	−0.0399	0.0148	−0.0021	0.0230	0.0005
Sweden	6.8677	0.0894	−0.0311	0.1345	−0.0474	0.0050	0.0059	0.0215	0.0010
United Kingdom	5.8772	0.1473	−0.1080	0.2235	−0.0367	0.0407	0.0009	0.0305	−0.0036
United States	5.3727	0.0966	−0.0189	0.1463	−0.0705	0.0253	−0.0027	0.0184	−0.0014

Continued.

Table A.5. *Continued.*

Economy	ϕ_{1995}	$\hat{g}^{\phi}$	Due to changes in θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7
European Union New Member States									
Bulgaria	0.5193	0.1419	−0.1345	0.1531	0.1146	−0.0118	−0.0049	0.0368	−0.0114
Cyprus	3.2515	0.2534	−0.1391	0.1699	0.1641	0.0293	0.0287	−0.0066	0.0072
Czech Republic	0.7240	0.1044	−0.1887	0.2139	0.0478	0.0218	−0.0016	0.0073	0.0039
Estonia	1.0897	0.2330	0.0911	0.1927	−0.1733	0.0584	0.0153	0.0474	0.0014
Hungary	1.2971	0.1457	−0.0201	0.0963	0.0661	−0.0064	−0.0039	0.0128	0.0009
Latvia	0.9416	0.2427	0.0712	0.2126	−0.0423	0.0100	0.0323	−0.0118	−0.0005
Lithuania	0.7045	0.2256	0.1236	0.0820	−0.0124	0.0200	0.0220	−0.0126	0.0031
Malta	2.3092	0.1506	−0.1522	0.2074	0.0823	0.0371	0.0028	−0.0169	−0.0100
Poland	1.7385	0.2183	−0.0432	0.1521	0.0289	0.0771	0.0026	−0.0068	0.0076
Romania	0.6998	0.0673	−0.2031	0.1872	0.0703	0.0109	−0.0027	0.0022	0.0025
Slovakia	0.6631	0.1397	0.1227	0.1081	−0.2260	0.0115	0.0115	0.0914	0.0206
Slovenia	4.5893	0.0635	−0.0042	0.1022	−0.0846	0.0248	0.0009	0.0241	0.0003
Non-Asian Developing									
Brazil	1.2283	0.0616	−0.0318	−0.0058	0.0795	0.0111	0.0006	0.0062	0.0018
Mexico	0.6301	0.2813	−0.0254	−0.0443	0.2919	0.0181	−0.0002	0.0403	0.0008
Russian Federation	1.3459	0.2180	−0.1452	0.2050	0.0943	0.0249	0.0066	0.0333	−0.0008
Turkey	0.7807	0.2802	−0.0689	0.1282	0.1398	0.0461	0.0134	0.0078	0.0139

Note: The figures for the different decompositions are the averages of the original and alternative decomposition.
Source: Authors' calculations.

Undervaluation, Financial Development, and Economic Growth

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This paper analyzes the effect of undervaluation on economic growth in the presence of borrowing constraints. Based on a two-sector, small open-economy model, we show that undervaluation can promote economic growth by partly correcting distortions in financial markets through the channels of increased within-sector productivity and the relative share of the tradable sector in an economy. Such an effect is magnified amid tight borrowing constraints. We empirically test the theoretical conclusions using cross-economy data for the period 1980–2011. For economies whose level of financial development lies at the 25th percentile of our sample, a 50% undervaluation can boost the economic growth rate by 0.3 percentage points. There is an additional 0.045 percentage point increase in economic growth with a 10% decline in the financial development measure.

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I. Introduction

There have been heated discussions over the effects of undervaluation on economic growth. On one side of the debate, there is a consensus that overvaluation, especially those of a large magnitude, can do great harm to economic growth. First, overvaluation discourages investment by lowering returns in the tradable sector (Bhaduri and Marglin 1990, Gala 2008). Second, overvaluation is often associated with problems like an unsustainable current account deficit or significant macroeconomic volatility (Dornbusch and Fischer 1980). Severe balance-of-payment crises due to exchange rate overvaluation were observed in many Latin American (e.g., Chile and Mexico) and African economies (e.g., Gabon and Zambia) in the early 1980s, as well as in Argentina, Brazil, and Mexico in the 1990s (Ngongang 2011). In developing economies, the deterioration in the current account deficit may encourage the government to tighten import quotas, which

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increases the probability of rent-seeking and corruption (Krueger 1974, Bleaney and Greenaway 2001).

On the other side, several empirical works (Dooley, Folkerts-Landau, and Garber 2004; Levy-Yeyati and Sturzenegger 2007; Rodrik 2008) find that undervaluation can play a significant role in promoting economic growth.[1] The reasons suggested in these papers diverge, with the former group emphasizing the role of capital deepening and savings accumulation driven by undervaluation, while the latter group views undervaluation as a correction for institutional defects and market failure. Even though there is no consensus on how undervaluation might promote economic growth, a consistent empirical fact is that the growth effect of undervaluation is much more prominent in developing economies than in developed economies. However, the existing literature does not provide a sound answer as to why there is such a difference in undervaluation's growth effect between developing and developed economies. Keeping this question in mind, the explanation we put forward in this paper is centered on an economy's level of financial development.

In the theoretical discussion below, we illustrate how borrowing constraints might amplify the growth effect of real currency undervaluation. Our model is closely related to that of Aghion et al. (2009), which show that, in the presence of a liquidity shock and wage stickiness, volatility in the real exchange rate will reduce the success probability of firms' research and development activities, thus lowering the aggregate growth rate. Such an effect is magnified in developing economies due to the existence of borrowing constraints. Based on their work, we establish a two-sector (tradable and nontradable), small open-economy model. There are two sources driving economic growth in our model: technological progress within the tradable sector and resource reallocation from the nontradable to the tradable sector. We also introduce firms' financial constraints in our model. At the end of the first period, each individual firm faces a stochastic liquidity shock after which only firms with sufficient funds can conduct the research and development needed to achieve a technology upgrade.

One of our conclusions is that if the exchange rate is sustained at the expected equilibrium level, the tradable sector suffers greater distortion due to binding financial constraints, as reflected in the lower probability of a technology upgrade in the tradable sector, which is driven by the difference in output elasticity of production between the tradable and nontradable sectors. If instead the policy of undervaluation is adopted under the assumption of wage stickiness, then domestic currency undervaluation is equivalent to an unexpected windfall for exporters.

[1]For example, the People's Republic of China has long been accused of manipulating its exchange rate by undervaluing the renminbi to promote exports and economic growth (Frankel 2003, Krugman 2003, Goldstein 2004).

Increased domestic product prices, coupled with sticky wages, can effectively raise a firm’s profit, which effectively relaxes the financial constraint and facilitates technological progress, leading to a within-sector productivity increase. Moreover, since the tradable sector is typically the sector with the faster rate of technological progress, the expansion of the tradable sector will accelerate the resource reallocation effect between sectors. In sum, domestic currency undervaluation can be seen as a way to correct a distortion in the finance sector by increasing both within-sector productivity and resource allocation efficiency between sectors.

How significant such a promotion effect can be depends on the level of development of an economy’s financial market. Specifically, the impact corresponds to the tightness of the financial constraint. In an economy that is characterized as having sufficient financial liquidity, all of its firms can survive a liquidity shock by engaging in intertemporal borrowing. Under such circumstances, there is no room for domestic currency undervaluation as a means of relaxing the financial constraint. Following such logic, we propose that the effect of domestic currency undervaluation on economic growth should be more significant at lower levels of financial development, which partly explains why developing economies have a preference for undervaluation.

This paper incorporates the findings in two distinct branches of literature. The first branch reviews the effects of currency undervaluation on economic growth, which has always been a major area of interest for both academics and policy makers. Most of the early empirical evidence supports the view that real exchange rate misalignment, when used as a form of price distortion, will have negative impacts on macroeconomic variables such as imports, exports, industrial structure, resource allocation, and income distribution. (Edwards 1988; Cottani, Cavallo, and Kahn 1990). At the same time, there is no difference found between the effects of currency overvaluation or undervaluation on economic growth in this research. Razin and Collins (1997) put forward that there might be some nonlinear correlation between real exchange rate misalignment and economic growth. According to their results, only very large overvaluations appear to be associated with slower economic growth. Moderate and high (as opposed to very high) undervaluations appear to be associated with more rapid economic growth. Specifically, a 10% overvaluation in the real exchange rate leads to a 0.6 percentage point decrease in the economic growth rate, while a 10% undervaluation contributes 0.9 percentage points to economic growth.

There are two traditional approaches in the literature to measuring the equilibrium real exchange rate. One is to use the fundamental equilibrium exchange rate (FEER) first proposed by Williamson (1985), who assumed macroeconomic balance. The other popular measurement is the behavioral equilibrium exchange rate (BEER), which focuses on the determinants of the exchange rate in the medium to long run (Baffes, Elbadawi, and O’Connell 1997; Maeso-Fernandez, Osbat, and

Schnatz 2002). Both approaches have pros and cons, but a common challenge is the availability of data, especially for developing economies.[2]

To include developing economies in our analysis, we refer to a different measure used by Rodrik (2008). Our equilibrium value of the real exchange rate is defined as the predicted real exchange rate based on gross domestic product (GDP) per worker after controlling for the fixed effects of economy and year. Real exchange rate misalignment is defined as the difference between the real value and fitted value, with a positive difference referring to currency undervaluation and a negative difference to overvaluation. The intuition behind such an approach is to conceive of the Balassa–Samuelson adjusted rate as the equilibrium. Prices in the nontradable sector should be lower in poorer economies, which will influence the real exchange rate through lower overall domestic prices. The advantage of this approach is to enable the comparison of currency undervaluation both in terms of cross-section and time series analysis. Moreover, it does not require as many economy-level macroeconomic variables as the two traditional measures, which makes it ideal for analyzing long-term panel data containing many developing economies.

A second branch of literature relates to the role of financial market development in economic growth. Financial activities have often been seen as responses to developments in the real economy and therefore the topic previously did not assume much importance within academia (Robinson 1972, Meier and Seers 1984). A case in point is Lucas (1988), who once commented that the role of finance on economic growth had been overstressed. As the understanding of incomplete information and market frictions deepened, a number of people realized the impact of finance on economic growth, especially on how financial intermediaries help to overcome the problem of adverse selection and improve the efficiency of credit allocation (Bagehot 1873, McKinnon 1973, Miller 1998). According to Levine (2005), there are five channels through which finance can stimulate economic growth: (i) producing information ex ante about possible investments and the allocation of capital; (ii) monitoring investments and exerting corporate governance after providing finance; (iii) facilitating the trading, diversification, and management of risk; (iv) mobilizing and pooling savings; and (v) easing the exchange of goods and services. Levine concludes that financial market development can stimulate economic growth by improving resource allocation and investment returns.

This paper contributes to the literature in three aspects. First, we try to explain the divergent effects of currency undervaluation on economic growth between developing and developed economies, which has become a stylized empirical fact lacking a solid explanation. What we find both theoretically and empirically is that the level of financial development is important in determining

[2]For a more detailed methodological comparison of BEERs and FEERs, please refer to Clark and MacDonald (1999).

currency undervaluation's effect on economic growth. We illustrate that currency undervaluation can partially compensate for the underdevelopment of financial markets and such an effect is magnified in less financially developed economies. Second, by using cross-economy data covering the period 1980–2011, we empirically quantify the effects of currency undervaluation on economic growth and separately examine the two channels through which currency undervaluation contributes to economic growth: (i) raising productivity within the tradable sector, and (ii) expanding the size of the tradable sector relative to the nontradable sector.

With regard to the policy implications, this paper deepens our understanding of why some developing economies have a preference for currency undervaluation. According to our explanation, developing economies with underdeveloped financial markets can use undervaluation as a remedy for tight financial constraints through the relaxation of such constraints in the tradable sector, which in turn stimulates economic growth.

The rest of the paper is organized as follows. Section II introduces our theoretical model and predictions. Section III describes the data and variables we have constructed. Section IV presents the benchmark estimates, describes a series of robustness checks, and explores the two channels through which undervaluation affects economic growth. Section V concludes.

II. Theoretical Model

In this section, we introduce our theoretical framework for further analysis. We consider a small, open-economy model in which wage stickiness is assumed in the short run. There are two sectors in the economy: tradable (T) and nontradable (N). The price for sector N is denoted as P_t^N. The tradable sector produces only a single good whose price is denoted as P_t^T. P_t^T is determined by the international market in our model. Normalizing the world price for the tradable good as 1, we have

$$P_t^T = S_t P_t^{T*} = S_t \tag{1}$$

where P_t^{T*} and S_t are the world price and nominal exchange rate, respectively.

The exchange rate, S_t, fluctuates around its equilibrium value, $E(S_t) = \bar{S}$. The equilibrium is the expectation value based on all historical information, which is consistent with the idea that the predicted value is formed using all available fundamentals.

We assume that wages are sticky in the short run. Following Aghion et al. (2009), it is assumed the wage rate at *t*-period is determined by

$$W_t^T = E\left(P_t^T\right)\kappa A_t^T = \bar{S}\kappa A_t^T,\ W_t^N = P_t^N \kappa A_t^N \tag{2}$$

which means the real wage in each of the two sectors is equal to sectorial productivity (A_t^T, A_t^N) times κ, where $\kappa < 1$ is the reservation utility (the utility gained while not working). Since the prices in the tradable sector are also influenced by fluctuation in the nominal exchange rate, the wage rate is determined by the expected equilibrium exchange rate, $E(P_t^T) = E(S_t) = \overline{S}$. The free mobility of labor will equalize wages in the two sectors ($W_t^T = W_t^N \triangleq W_t$); such an equation can also be used to determine the price level of the nontradable sector (P_t^N).

A. Firm Decision

The wage rate at the beginning of the first period is the function of the expected equilibrium exchange rate so that a firm's decision is a two-period problem. First, based on the known distribution of a liquidity shock, the firm speculates the probability of achieving a technology upgrade. The labor demand is determined by maximizing the expected sum of revenues over the two periods. At the end of each period, the stochastically distributed liquidity shock is realized and only those firms that succeed in raising sufficient funds can complete the technology upgrade and realize the associated profit (υ_{t+1}). The sectorial productivity is determined by the proportion of firms succeeding in innovation (ρ_t).

Assuming labor is the only input, the production functions in the tradable and nontradable sectors take the following forms:

$$
\begin{aligned}
y_t^T &= A_t^T (l_t^T)^{\alpha^T} \\
y_t^N &= A_t^N (l_t^N)^{\alpha^N} \qquad (3)
\end{aligned}
$$

To guarantee that profits can be allocated for technological innovations, we consider the case of decreasing returns to scale. Moreover, it is assumed that the output elasticity of labor is larger in the nontradable sector:[3]

$$1 > \alpha^N > \alpha^T \qquad (4)$$

[3]We discuss more on the validity of assumption $1 > \alpha^N > \alpha^T$ here. If the production function takes the Cobb–Douglas form, then the assumption $\alpha^N > \alpha^T$ implies that the nontradable sector is more labor intensive than the tradable sector, which is also a basic assumption in Herrendorf, Rogerson, and Valentinyi (2013). To measure labor intensity, several major indexes are used. For data at the firm level, these include employer's compensation/total assets (Dewenter and Malatesta 2001) and employer's compensation/sales (Grubaugh 1987). For data at the industry level, a frequently used index is industrial labor compensation/industrial nominal value-added output (Acemoglu and Guerrieri 2006). In order to enable summary statistics covering as many economies as possible, we use industrial labor compensation/value-added output from the World Bank's World Development Indicators to proxy for labor intensity. Our sample includes 214 economies covering the period 1960–2014. The mean value of labor intensity is 0.81 in the manufacturing sector and 1.01 in the service sector. Broken down into subperiods, the mean values for the manufacturing and service sectors in 1960–1980 are 0.72 and 0.98, respectively. For 1981–2014, the corresponding figures are 0.83 and 1.02, respectively. Therefore, on average, the nontradable (services) sector is more labor intensive than the tradable (manufacturing) sector, which is compatible with the assumption $\alpha^N > \alpha^T$.

The profits at the end of the first period are

$$\pi_t^T = P_t^T y_t^T - W_t l_t^T = A_t^T S_t (l_t^T)^{\alpha^T} - \bar{S}\kappa A_t^T l_t^T$$
$$\pi_t^N = P_t^N y_t^N - W_t l_t^N = A_t^N P_t^N (l_t^N)^{\alpha^N} - P_t^N \kappa A_t^N l_t^N \tag{5}$$

We need to assume that wages are sticky in the short run because the wage level is determined by the expectation formed at the beginning of each period. When the realized exchange rate value (S_t) deviates from $\bar{S}$, the wage paid will not change in the short run. Instead, only the product price and labor demand will be affected. Only when there is a divergence of the realized value with the equilibrium level can the profit in the tradable sector be altered, which further impacts the tightness of the borrowing constraint.

In the maximization problem of the firm, the decision variable is labor demand (l_t), which affects the firm's profit at the end of the first period (π_t) and further determines the upper bound of the borrowing constraint in the presence of a liquidity shock. All of these factors affect the chance for success of a technology upgrade in the second period (ρ_t) as the firm maximizes the expected sum of revenues over two periods:

$$\max_{l_t^S} \left\{ \pi_t^S + \beta \rho_t^S E_t \upsilon_{t+1} \right\}, S = T, N \tag{6}$$

B. Technology Upgrading and Borrowing Constraint

In each period, both sectors T and N can upgrade their technology by the multiplier $\gamma > 1$, meaning that in the next period the productivity of firms achieving innovation will be the following:[4]

$$A_{t+1}^S = \gamma A_t^S, S = T, N \tag{7}$$

Furthermore, we assume the realized value after innovation is proportional to the nominal productivity in the next period:

$$V_{t+1}^S = \upsilon P_{t+1}^S A_{t+1}^S, S = T, N \tag{8}$$

υ is assumed to be sufficiently large so that innovation is profitable for firms in both sectors. That is to say, in the absence of a borrowing constraint, all firms will choose to make a technology upgrade, which will result in a growth rate of $\gamma > 1$

[4]For simplicity, the rates of technology upgrading are assumed to be equalized across the two sectors. In cases of the tradable sector having a faster rate ($\gamma^T > \gamma^N$), our main conclusions still hold. In fact, the results are strengthened.

for the whole economy. However, firms face a borrowing constraint in our setup: it is assumed that the funds a firm can borrow should be no more than $\mu - 1$ times its realized profit (π_t) at the end of period t. Equivalently, the maximum amount of capital available is $\mu\pi_t$. The parameter μ indicates the level of development of the financial market (or, more explicitly, the tightness of the borrowing constraint). The smaller μ is, the harder it is for firms to borrow. Contrarily, if μ is sufficiently large, then all capital demands can be satisfied and there is no borrowing constraint.

Firm i will confront a liquidity shock at the end of period t, $(C_t)_i$, which can also be seen as the amount of liquidity needed for innovation. Whether or not the liquidity requirement is satisfied determines the success or failure of innovation. If the financial market is perfect, then all firms can survive the liquidity shock by relying on intertemporal borrowing. The probability of firms successfully achieving a technology upgrade is 1, and the overall growth rate is constant. It is the presence of a borrowing constraint that leads to only some firms achieving a technology upgrade. The impact of such a shock is assumed to be proportional to a firm's nominal productivity at period t:

$$(C_t^S)_i = c_i P_t^S A_t^S, S = T, N \tag{9}$$

where c_i is assumed to be independent and identically distributed across all firms with a cumulative distribution function of $F(.)$.

Consequently, only those firms satisfying $\mu\pi_t^S \geq C_t^S$ (those firms with sufficient funds) can survive a liquidity shock and achieve a technology upgrade. As a result, the probabilities of firms achieving innovation in each of the two sectors are

$$\rho_t^S = Pr\left(c_i \leq \frac{\mu\pi_t^S}{P_t^S A_t^S}\right) = F\left(\frac{\mu\pi_t^S}{P_t^S A_t^S}\right), S = T, N \tag{10}$$

C. Equilibrium Profit

Plugging the expression ρ_t^S into the maximization problem of the firm results in

$$l_t^T = \left(\frac{\alpha^T S_t}{\kappa \bar{S}}\right)^{\frac{1}{1-\alpha^T}}, l_t^N = \left(\frac{\alpha^N}{\kappa}\right)^{\frac{1}{1-\alpha^N}} \tag{11}$$

Plugging l_t^S into the profit functions of each sector results in

$$\pi_t^T = A_t^T S_t \left(1 - \alpha^T\right) \left(\frac{\alpha^T S_t}{\kappa \bar{S}}\right)^{\frac{\alpha^T}{1-\alpha^T}} \triangleq A_t^T S_t \Psi^T \left(\frac{S_t}{\bar{S}}\right)^{\frac{\alpha^T}{1-\alpha^T}}$$

$$\pi_t^N = A_t^N P_t^N \left(1-\alpha^N\right)\left(\frac{\alpha^N}{\kappa}\right)^{\frac{\alpha^N}{1-\alpha^N}} \triangleq A_t^N P_t^N \Psi^N \tag{12}$$

From equation (10), we know the probability of completing the innovation is

$$\rho_t^T = F\left(\mu\Psi^T\left(\frac{S_t}{\bar{S}}\right)^{\frac{\alpha^T}{1-\alpha^T}}\right), \rho_t^N = F\left(\mu\Psi^N\right) \tag{13}$$

where $\Psi^S = (1-\alpha^s)\left(\frac{\alpha^s}{\kappa}\right)^{\frac{\alpha^S}{1-\alpha^S}}, S = T, N$

From equation (13), we can see that if the exchange rate remains at its equilibrium value ($S_t = \bar{S}$), then the probabilities of a technology upgrade in the tradable and nontradable sectors are time invariant. Instead, they depend only on the borrowing constraint parameter (μ), the reservation utility (κ), and the labor intensity parameter ($\alpha^S, S = T, N$). Producers will adjust their factor demands at the beginning of each period. For a comparison between sectors, the relative magnitudes of the technology upgrade probabilities depend only on the parameters Ψ^T, Ψ^S. Since the output elasticity of labor is larger in the nontradable sector ($\alpha^N > \alpha^T$), it proves that $\Psi^T < \Psi^N$.[5] Further, we have $\rho^T < \rho^N$. Our conclusions based on these findings are summarized below.

Conclusion 1: *If the exchange rate remains at the equilibrium level and the borrowing constraint is binding, then the probability of achieving innovation is lower in the tradable sector than in the nontradable sector.*

As we have proved, real currency undervaluation ($S_t > \bar{S}$) will have two effects on the tradable sector. One is the relative expansion of the tradable sector, both in terms of employment and output, with the magnitude amplified if measured in nominal terms. The other effect is the increased probability of a technology upgrade in this sector when μ is finite. This explains why some developing economies have a preference for an exchange rate policy based on undervaluation. One possible reason is that intentional undervaluation relaxes the borrowing constraint in the tradable sector, which is characterized as having higher productivity than the tradable sector (Rodrik 2008). However, when μ is sufficiently large, the financing demands of all firms can be satisfied and there is no borrowing constraint. Then $\rho_t^T, \rho_t^N \to 1$ holds and the effect on ρ_t^T due to the increase in S_t will be very trivial, which implies the increased probability of a technology upgrade in the tradable sector will be more significant in economies with a less developed financial market.

Conclusion 2: *Real exchange rate undervaluation will lead to the expansion of the tradable sector.*

[5]To derive $\Psi^T < \Psi^N$ from $\alpha^T < \alpha^N$, we can define a function $\Psi(\alpha) = (1-\alpha)(\alpha/\kappa)^{\frac{\alpha}{1-\alpha}}$. By calculating the log of both sides and then calculating the derivative with respect to α, $\Psi(\alpha)$ increases in α so that $\Psi^T < \Psi^N$.

Conclusion 3: *Real exchange rate undervaluation will increase the probability of technology upgrading in the tradable sector. Such an effect is magnified in economies with less developed financial markets.*

D. Economic Growth Rate

Next, we come to evaluate the impact of the real exchange rate on the economic growth rate. If we assume that the nominal exchange rate at period $t-1$ remains $\overline{S}$ (equilibrium level), then the real output in each of the two sectors is

$$y_{t-1}^{T} = A_{t-1}^{T}\left(\frac{\alpha^{T}}{\kappa}\right)^{\frac{\alpha^{T}}{1-\alpha^{T}}},\ y_{t-1}^{N} = A_{t-1}^{N}\left(\frac{\alpha^{N}}{\kappa}\right)^{\frac{\alpha^{N}}{1-\alpha^{N}}} \tag{14}$$

When there is misalignment in the real exchange rate at period t, which means the realized value (S_t) deviates from $\overline{S}$, then the output in each of the two sectors is

$$\begin{aligned} y_t^T &= [\rho_t^T \gamma A_{t-1}^T + \left(1-\rho_t^T\right) A_{t-1}^T]\left(\frac{\alpha^T S_t}{\kappa \overline{S}}\right)^{\frac{\alpha^T}{1-\alpha^T}} = y_{t-1}^T[\rho_t^T \gamma \\ &\quad + \left(1-\rho_t^T\right)]\left(\frac{S_t}{\overline{S}}\right)^{\frac{\alpha^T}{1-\alpha^T}} \\ y_t^N &= [\rho_t^N \gamma A_{t-1}^N + \left(1-\rho_t^N\right) A_{t-1}^N]\left(\frac{\alpha^N}{\kappa}\right)^{\frac{\alpha^N}{1-\alpha^N}} = y_{t-1}^N[\rho_t^N \gamma + \left(1-\rho_t^N\right)] \end{aligned} \tag{15}$$

Consequently, the gross growth rate of real output is

$$\begin{aligned} g_t &= \frac{y_t}{y_{t-1}} = \frac{y_t^T + y_t^N}{y_{t-1}^T + y_{t-1}^N} = \frac{y_t^T}{y_{t-1}^T} v_{T,t-1} + \frac{y_t^N}{y_{t-1}^N}\left(1 - v_{T,t-1}\right) \\ &= [\rho_t^T \gamma + \left(1-\rho_t^T\right)]\left(S_t/\overline{S}\right)^{\frac{\alpha^T}{1-\alpha^T}} .v_{T,t-1} + \left[\rho_t^N \gamma + \left(1-\rho_t^N\right)\right](1 - v_{T,t-1}) \end{aligned} \tag{16}$$

where $v_{T,t-1} = \frac{y_{t-1}^T}{y_{t-1}^T + y_{t-1}^N}$, which is the output share of the tradable sector at period $t-1$.

Given equations (11) and (13), we know that neither the probability of a technology upgrade in the nontradable sector (ρ_t^N) nor the output at different phases will be changed by nominal exchange rate movement. Instead, the only channel for nominal exchange rate movement to affect the gross growth rate is through output change in the tradable sector. It can be seen clearly from equation (16) that, in the presence of a borrowing constraint, undervaluation affects the growth rate of real output mainly in two ways: (i) by increasing ρ_t^T (more firms can achieve a technology upgrade in period t), which leads to an accelerated technology growth rate in the tradable sector; and (ii) by changing the relative price between sectors (increase in $S_t/\overline{S}$), which will result in more labor and more output in the tradable sector (industrial structure change).

If the price factor is taken into consideration, the nominal effect of real exchange rate undervaluation on the growth rate will be even larger. This is because, on one side, the relative price in the tradable sector rises as expressed in the increase of $S_t/\overline{S}$. On the other side, due to the equalization of wages across the two sectors, the price in the nontradable sector also increases. From equation (2), we know

$$\begin{aligned} P_t^N/P_{t-1}^N &= (A_t^T/A_{t-1}^T)/(A_t^N/A_{t-1}^N) \\ &= \frac{\rho_t^T\gamma + \left(1-\rho_t^T\right)}{\rho_t^N\gamma + \left(1-\rho_t^N\right)} \end{aligned}$$

When there is an undervaluation, ρ_t^T increases while ρ_t^N remains unchanged. Therefore, a technology upgrade in the tradable sector will pull up the price in the nontradable sector, which is consistent with the spirit of the Balassa–Samuelson effect. In the case of the nominal growth rate, nominal exchange rate undervaluation, which is associated with undervaluation, will increase prices in both sectors, making the nominal increase larger in magnitude than the result measured in real terms.

Conclusion 4: *Real exchange rate undervaluation will affect the real economic growth rate in two ways: (i) increased productivity within the tradable sector and (ii) the expansion of the tradable sector since increased relative prices will attract more resources into the sector. When measured in terms of the nominal growth rate, the effect of undervaluation on growth is further magnified because of increased prices in both sectors.*

III. Data and Variables

A. Key Variables

In this section, we test conclusions 2–4 by using cross-economy data. One conclusion from the model is that real exchange rate undervaluation can promote economic growth and that such an effect is greater in economies at lower levels of financial development. To test this hypothesis, we define our key explained variable—real exchange rate misalignment—as the difference between the realized value of the real exchange rate and its equilibrium. The accuracy of the "equilibrium real exchange rate" determines the precision of the explained variable. As discussed in the introduction, commonly used approaches such as FEER and BEER are more suitable for time series data for a single economy and panel data for developed economies. However, the data set we prefer is a sample covering most developed and developing economies over a longer span. Due to the limitations of the data, especially for developing economies, we prefer the measure introduced by Rodrik (2008) for the sake of comparisons between different economies and time spans.

Following Rodrik (2008), we construct the measurement of real exchange rate undervaluation in three steps. First, we calculate the real exchange rate

$$\ln RER_{ct} = \ln\left(\frac{XRAT_{ct}}{PPP_{ct}}\right)$$

where the subscripts c and t denote economy and year, respectively. *XRAT* represents the US dollar-denominated value of the domestic currency and *PPP* is the relative purchasing power conversion factor. When RER_{ct} is less than 1, the nominal currency value in economy c is lower than the equilibrium level measured in terms of purchasing power parity. However, it does not necessarily indicate an undervalued currency in economy c since less developed economies are associated with lower prices for nontradable goods, which is the essence of the Balassa–Samuelson effect.

To deconstruct the Balassa–Samuelson effect, we then regress the real exchange rate on GDP per capita ($RGDPPC_{ct}$) with the time fixed effect controlled:

$$\ln RER_{ct} = \alpha + \beta \ln RGDPPC_{ct} + f_t + u_{ct}$$

where f_t is the time fixed effect. The regression result indicates that $\hat{\beta} = -0.3$ with an associated t-value of -3.6, which means that given a 10% increase in GDP per capita, there will be a 3% appreciation in the real exchange rate.

The third step is to define the undervaluation index as the difference between the realized exchange rate and the predicted value derived from the first two steps.

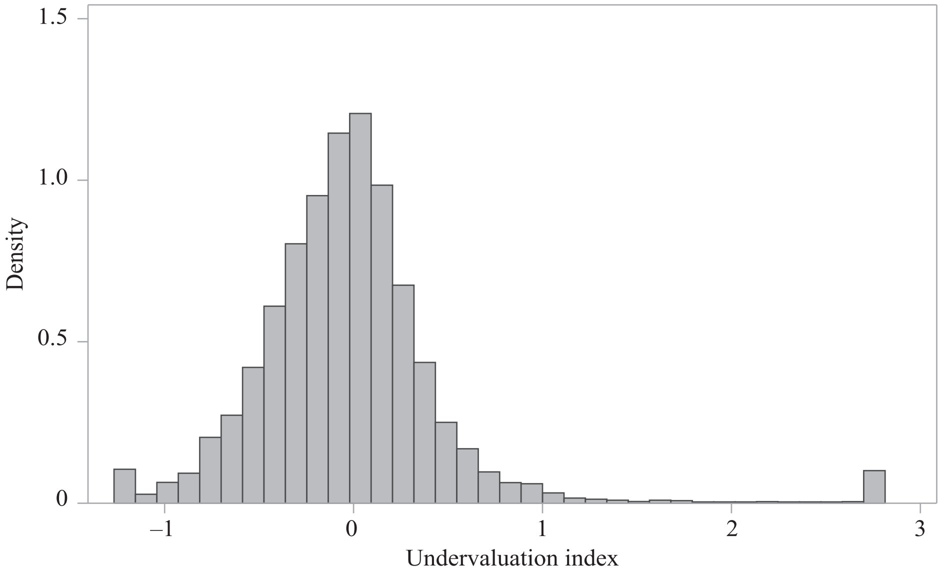
$$\ln UNDERVAL_{ct} = \ln RER_{ct} - \ln \widehat{RER}_{ct}$$

$\ln \widehat{RER}_{ct}$ is the expected equilibrium value for the exchange rate and $\ln RER_{ct}$ is the realized value. When $UNDERVAL_{ct}$ for economy c is greater than 1, the domestic currency is undervalued. The real exchange rate misalignment index can be compared between different economies and periods. Plotting the distribution of exchange rate misalignment (after taking the logarithm), we observe in Figure 1 that most of the dots are scattered near zero and the standard deviation is 0.77.

The measurements for financial development are consistent with Levine, Loayza, and Beck (2000). We use two measures: (i) private credit/GDP and (ii) M2/GDP. The first index is used for the benchmark result (Figure 2) and the second is used as a robustness check (Figure 3).

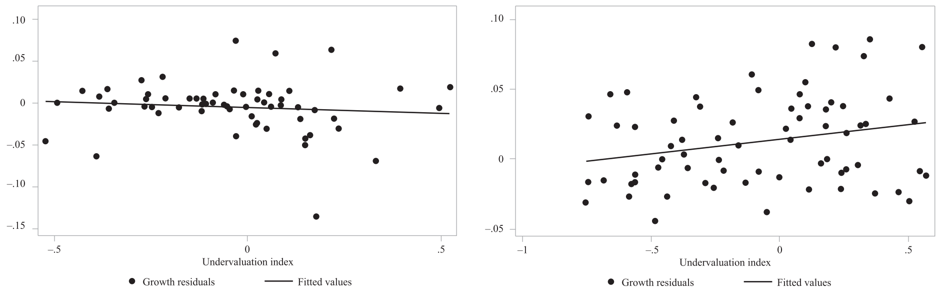
To examine how the correlation between undervaluation and economic growth varies in economies with different levels of financial development, we divide

Figure 1. **Distribution of Real Exchange Rate Undervaluation**



Note: The value of real exchange rate undervaluation is in logarithmic form and the 1% outliers have been dropped.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc/data/pwt/

Figure 2. **Correlation between Undervaluation and Economic Growth**

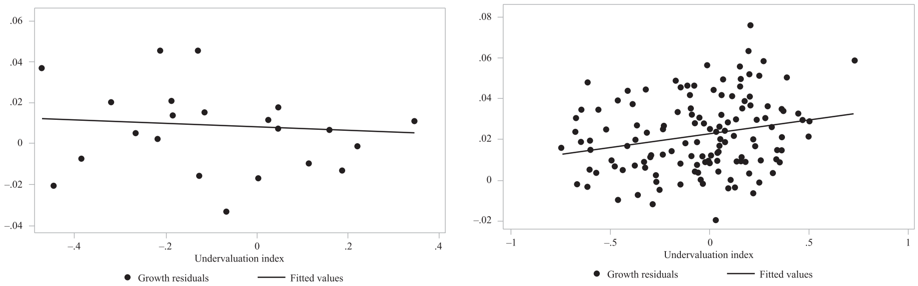


Highest quartile of financial development

Lowest quartile of financial development

Notes:
1. Financial development is measured by private credit/gross domestic product (GDP).
2. The economic growth rate is the residual of regressing real GDP per worker on a series of control variables (real GDP per worker in last period, private credit/GDP, dependency ratio, investment ratio, and government expenditure ratio).
3. The currency undervaluation is measured based on Rodrik, Dani. 2008. "The Real Exchange Rate and Economic Growth." *Brookings Papers on Economic Activity* 2 (2008): 365–412.
4. The data are averaged over the period 1908–2011.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc/data/pwt/

Figure 3. **Correlation between Undervaluation and Economic Growth**



Highest quartile of financial development

Lowest quartile of financial development

Notes:
1. Financial development is measured by M2/gross domestic product (GDP).
2. The economic growth rate is the residual of regressing real GDP per worker on a series of control variables (real GDP per worker in last period, private credit/GDP, dependency ratio, investment ratio, and government expenditure ratio).
3. The currency undervaluation is measured based on Rodrik, Dani. 2008. "The Real Exchange Rate and Economic Growth." *Brookings Papers on Economic Activity* 2 (2008): 365–412.
4. The data are averaged over the sample period.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc/data/pwt/

economies into four groups according to their financial development performances (measured in terms of either private credit/GDP or M2/GDP), and we compare the economies in the lowest quartile with the ones in the highest quartile. The right panel of Figure 2 shows that when using private credit/GDP to measure financial development, there is a significant positive correlation between undervaluation and economic growth in the lowest quartile.[6] However, the left panel of Figure 2 shows that this correlation disappears in economies whose financial markets rank in the top quartile. This divergent pattern of correlation holds when we replace the financial market development index with M2/GDP as shown in Figure 3.

B. Empirical Analysis

The regression takes the following specification based on Rodrik (2008):

$$\begin{aligned} growth_{ct} &= \alpha + \beta.\, lny_{c,t-1} + \gamma_1.\, Underval_{ct} + \gamma_2.\, Underval_{ct} * Fin\ devt_{ct} \\ &\quad + \gamma_3.\, Fin\ devt_{ct} + \delta.\, Z_{c,t-1} + \theta_c + \theta_t + \varepsilon_{ct} \end{aligned} \tag{17}$$

where $growth_{ct}$ is the growth rate of domestic output per worker for economy c in year t. $lny_{c,t-1}$ is real GDP per worker in period $t-1$. $Underval_{ct}$ is our

[6]For economies whose level of financial development falls in the bottom one-third of our sample there is a consistent positive correlation between undervaluation and economic growth.

Table 1. **Summary Statistics**

Variable	**Mean**	**Standard Deviation**
Real GDP per worker	9.5	1.2
Undervaluation	−0.1	0.8
Dependency ratio	0.7	0.2
Trade openness	0.6	0.7
Government expenditure share (% of GDP)	0.2	0.1
Investment share (% of GDP)	0.2	0.1
M2/GDP	3.7	0.7
Private credit (% of GDP)	3.4	1.0

GDP = gross domestic product.
Notes: Real gross domestic product (GDP) per worker, undervaluation, M2/GDP, and private credit/GDP are in logarithmic form.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc/data/pwt/

constructed measurement of undervaluation for economy c. $Fin\ devt_{ct}$ indicates the financial development for economy c. θ_c and θ_t are the fixed effects for economy and year, respectively. $Z_{c,t-1}$ includes several control variables at the economy level, including the dependency ratio (ratio of people younger than 15 or older than 64 years of age to the working-age population comprising those aged 15–64 years), trade openness (sum of exports and imports of goods and services as % of GDP), government expenditure share (% of GDP), and investment share (gross fixed capital formation as % of GDP). All control variables except for $Underval_{ct}$ and $Fin\ devt_{ct}$ are uniformly in lagged form in order to alleviate the concern of reverse causality or other endogeneity problems.

Our sample covers 156 economies for the period 1980–2011. The summary statistics are listed in Table 1.

IV. Empirical Results

A. Effect of Undervaluation on Economic Growth

Based on equation (17), we estimate the overall effect of undervaluation on the economic growth rate. The results are listed in Table 2. As to the measure of financial market development, we use private credit (value of credit extended to the private sector by banks and other financial intermediaries) as a share of GDP, which is a standard indicator in the related literature. This is superior to other measures of financial development in that it excludes credit granted to the public sector and funds provided from central or development banks. For a robustness check, we present results with financial market development measured as M2/GDP.

The impact of undervaluation on economic growth is generally positive, though sometimes insignificant. The significantly negative sign of the interactive

Table 2. **Effect of Undervaluation on Economic Growth Rate**
Dependent variable: economic growth rate (*growth*$_{ct}$)

	(1) fin_devt = private credit/GDP	**(2)** fin_devt = private credit/GDP	**(3)** fin_devt = 1(private credit/GDP > 25$^{\text{th}}$ percentile)	**(4)** fin_devt = 1(private credit/GDP > 50$^{\text{th}}$ percentile)	**(5)** fin_devt = 1(private credit/GDP > 75$^{\text{th}}$ percentile)
Real GDP per worker$_{t-1}$	−0.063*	−0.064*	−0.063*	−0.065*	−0.065*
	(−11.56)	(−11.68)	(−12.11)	(−12.30)	(−12.35)
Underval	0.005	0.030***	0.008	0.015**	0.011
	(0.85)	(1.95)	(1.41)	(2.29)	(1.43)
Fin devt	0.002	0.002	−0.014*	−0.006	0.003
	(0.63)	(0.48)	(−3.23)	(−1.44)	(0.59)
Underval ∗ fin devt		−0.009***	−0.031*	−0.032*	−0.016***
		(−1.76)	(−3.33)	(−3.74)	(−1.80)
Dependency ratio$_{t-1}$	−0.000	−0.000	−0.000	−0.000***	−0.000
	(−1.22)	(−1.44)	(−1.52)	(−1.81)	(−1.51)
Trade openness$_{t-1}$	0.010*	0.010*	0.010*	0.011*	0.010*
	(3.19)	(3.19)	(3.18)	(3.35)	(3.20)
Govt. expenditure share$_{t-1}$	−0.069*	−0.076*	−0.064*	−0.072*	−0.074*
	(−3.23)	(−3.50)	(−3.16)	(−3.55)	(−3.59)
Investment share$_{t-1}$	0.041***	0.038***	0.032	0.029	0.026
	(1.85)	(1.70)	(1.52)	(1.40)	(1.26)
Fixed effects					
Economy fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	4,019	4,019	4,019	4,019	4,019
R^2	0.084	0.084	0.087	0.086	0.083

GDP = gross domestic product.
Notes:
1. All observations are annual data for the period 1980–2011.
2. The measure of financial development is private credit as a percentage of GDP.
3. Undervaluation and private credit/GDP are in logarithmic form.
4. All regressions include a constant term and economy and year fixed effects, and control for the main effects of all three shocks.
5. t-statistics are in parenthesis.
6. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc/data/pwt/

term (*underval* × *fin devt*) suggests that the effect of undervaluation is much greater in economies at lower levels of financial development. In column (1), we find no significant effect on the economic growth rate. However, when the interactive term for undervaluation and financial development is added in column (2), we find its sign is significant and negative, indicating a stronger growth stimulation effect of undervaluation in economies with less developed financial markets. For instance, in economies whose financial development lies at the 25th percentile of the distribution, the mean value of financial development is 2.67. Therefore, a 50% undervaluation can increase the economic growth rate by 0.3 percentage points (50% ∗ [0.03–0.009 ∗ 2.67]). Moreover, the coefficient of the interactive term implies that given a 50% undervaluation, there will be an additional 0.045 percentage point increase in economic growth with every 10% decline in the level of financial development (50% ∗ 0.009 ∗ 10%).

The first two columns are derived using a continuous measurement for financial development. However, the effect of finance on economic development may be nonlinear. To deal with this possibility, in columns (3), (4), and (5) we divide economies into two groups (less developed and more developed) according to their relative rank of financial development, with thresholds set at the 25th, 50th, and 75th percentiles, respectively. The dummy value is set as 1 for the more developed group and then this dummy variable is interacted with the undervaluation index. The coefficients of the interactive term are significantly negative, proving again the weaker effect of undervaluation on economic growth in economies with more advanced finance sectors.

In column (3), the coefficient of the interactive term is –0.031, suggesting that compared with economies whose financial development falls below the 25th percentile, the effect of a 50% undervaluation on economic growth is 1.5 percentage points (50% ∗ 0.031) less in those economies with more advanced financial markets. Similarly, in columns (4) and (5), where the dividing lines are set at the 50th and 75th percentiles of the financial development distribution, respectively, the interactive terms remain uniformly negative, reinforcing the idea that economies with less developed financial markets benefit more from undervaluation in terms of growth.

The results for other control variables are by and large consistent with the literature in that higher GDP per worker in the previous period is associated with a slower growth rate, which is in line with convergence theory (Barro and Sala-i-Martin 1992). As for the magnitude, in a related empirical study on undervaluation, Rodrik (2008) reports the coefficients for lagged real income per capita for developed and developing economies as –0.055 and –0.065, respectively. As for the partial derivative of *findevt*, the relationship between *findevt* and growth can be ambiguous. Compared with less developed economies, advanced economies may perform better in terms of both *findevt* and growth. On the other hand, advanced economies with more developed financial markets may grow more slowly than some emerging economies. The significantly negative role of *findevt* may be explained by the faster growth rate of those economies that are catching up, which is the essence of the convergence theory of economic growth. For the demographic variable, a higher dependency ratio lowers the economic growth rate (Krugman 1995, Higgins and Williamson 1997).

Assessing the impact of government expenditure on economic growth is quite controversial. Barro (1990) proposes the promotion effect of government expenditure in an endogenous growth model in which public expenditure is seen as part of the production input. Conversely, many empirical works provide evidence of the opposite (Landau 1983, Grier and Tullock 1989), which coincides with what we find in our paper that government expenditure has a negative effect on growth. Empirically, the magnitude of government spending on economic growth varies and depends largely on the selection of the sample and the definition of government spending. Likewise, a possible mechanism for trade openness may be what is stressed by Young (1991) and Yanikkaya (2003), who note that open trade may hurt an individual economy even though it is beneficial for economies as a whole.

B. Robustness Check

In Table 3, we test the robustness of our results in two directions: (i) by altering the measures of our key variables: financial development and undervaluation and (ii) by further reporting the results using 5-year-averaged panel and cross-section data instead of adopting yearly panel data.

First, for an alternative measure of financial development, we refer to M2/GDP (Levine and Zervos 1996, 1998; Demirgüç-Kunt and Levine 1996). In column (1), the results are qualitatively consistent with the benchmark. To be more specific, the sample mean of financial development is 3.72, implying that the growth effect driven by a 50% undervaluation is 0.14 percentage points (50% $*$ [0.081–0.021 $*$ 3.72]) on average. Furthermore, given a 50% undervaluation, with every 10% decline in financial development, the marginal effect on economic growth is amplified by 0.11 percentage points (50% $*$ 10% $*$ 0.021).

Another key variable is undervaluation, which depends on the accuracy of the real exchange rate. In the benchmark regression, the real exchange rate is constructed based on Penn World Tables 8.0. For a robustness check, we turn to the counterpart variable from the International Monetary Fund and the results are listed in column (2). Compared with the Penn World Tables 8.0, the International Monetary Fund sample is much smaller, which leads to a sharp decrease in observations from 4,019 to 1,960. However, despite such a drop in the number of observations, the results are still qualitatively consistent and remain highly significant.

In columns (3) and (4), we report the results using data in 5-year-averaged panel and cross-sectional forms, respectively. In the cross-sectional regression, all of the control variables are averaged over the sample year, while real GDP per worker$_{t-1}$ refers to the value at the beginning year. The main conclusion that undervaluation can promote economic growth still holds. Such an effect is more prominent in less developed financial markets.

We will now discuss the threshold of *findevt* that makes the partial effect of undervaluation positive. According to equation (17), the threshold equals $-\gamma_1/\gamma_2$. When *findevt* is measured as private credit/GDP (in logarithmic form), the threshold values range from 2.9 to 4.7 (see column [2] of Table 2 and columns [2]–[4] of Table 3), depending on the data source of the real effective exchange rate

Table 3. **Robustness Check**
Dependent variable: economic growth rate ($growth_{ct}$)

Financial development measure	**M2/GDP**	**Private credit/GDP**	**Private credit/GDP**	**Private credit/GDP**
RER construction source	**PWT 8.0**	**IMF**	**PWT 8.0**	**PWT 8.0**
Data	**panel**	**panel**	**5-year-averaged panel**	**cross-section**
	(1)	**(2)**	**(3)**	**(4)**
Real GDP per worker$_{t-1}$	−0.060*	−0.047*	−0.099*	−0.013*
	(−10.91)	(−6.66)	(−15.71)	(−8.15)
Underval	0.081*	0.066*	0.047**	0.020***
	(3.32)	(5.81)	(2.34)	(1.97)
Fin devt	−0.016*	−0.011*	0.002	0.001
	(−2.94)	(−2.70)	(0.60)	(0.34)
Underval × fin devt	−0.021*	−0.020*	−0.010**	−0.007***
	(−3.09)	(−5.42)	(−2.31)	(−1.72)
Dependency ratio$_{t-1}$	−0.000	0.000	−0.000	−0.001*
	(−1.60)	(1.01)	(−1.32)	(−6.75)
Trade openness$_{t-1}$	0.010*	0.045*	0.014**	0.006**
	(3.18)	(5.32)	(2.26)	(2.49)
Govt. expenditure share$_{t-1}$	−0.065*	−0.022	−0.054**	−0.029***
	(−3.00)	(−0.76)	(−2.08)	(−1.83)
Investment share$_{t-1}$	0.037***	0.013	0.037	0.059*
	(1.65)	(0.43)	(1.23)	(3.23)
Fixed effects				
Economy fixed effect	Yes	Yes	Yes	
Year fixed effect	Yes	Yes	Yes	
Observations	3,682	1,960	677	127
R^2	0.090	0.110	0.388	0.488

GDP = gross domestic product, IMF = International Monetary Fund, PWT = Penn World Tables, RER = real effective exchange rate.
Notes:
1. Observations are annual data for the period 1980–2011.
2. The measures of financial development are the same as indicated in the column headings.
3. Both undervaluation and private credit/GDP are in logarithmic form.
4. Panel regressions in columns (1)–(3) include both economy and year fixed effects. Column (4) reports the estimates of cross-sectional data where all of the control variables are averaged over the period 1980–2011 and real GDP per worker$_{t-1}$ refers to the value at the beginning year.
5. t-statistics are in parenthesis.
6. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc/data/pwt/

(International Monetary Fund or Penn World Tables 8.0) and the structure of data (yearly panel, 5-year-averaged panel, or cross section). In our sample, the threshold value lies around the 50th percentile of the whole distribution. As an example, the threshold is close to the financial development level of economies like Mexico and Peru in 2011, which implies that for economies whose financial markets are less developed than the threshold level, the adoption of undervaluation may promote economic growth. Similarly, when *findevt* is measured as M2/GDP (in logarithmic form) in column (1) of Table 3, the corresponding threshold value is 3.86, which is very close to the relative rank suggested by using private credit/GDP.

C. Endogeneity

The possible endogeneity of an economy's financial development level leads to concerns of biased estimates (Arellano and Bond 1991, Blundell and Bond 1998). To tackle this issue, we adopt a generalized moment method. By taking the differences of the forward term of explanatory variables together with the lagged explained variables as instrument variables, we try to alleviate the possible endogeneity of the dynamic panel data.

Table 4 shows that the results are still very robust with the generalized moment method estimation: the positive effect of undervaluation on economic growth is again more prominent for economies with less developed financial markets. Moreover, the coefficient of the interactive term is close to the results presented in Table 2. To check the fitness of our specifications, we report the value of AR(2) to test whether there is autocorrelation of the second order residuals; our result rejects this possibility. The validity of instrument variable gains is also supported by the results shown in the last row of Table 4.

D. Channels Verification

We have thus far examined the overall effect of undervaluation on economic growth. In this section, we go a step further to verify the two channels implied in the theoretical model. Equation (16) shows that undervaluation can stimulate economic growth via two channels: (i) expanding the share of the tradable sector in the economy, and (ii) increasing productivity within the tradable sector.

The quantified results for the first channel are reported in Table 5. When using the ratio of industrial output to GDP as a proxy for the tradable sector's share of the economy, we find that undervaluation increases this share. This effect is more prominent at lower levels of financial development. The sample mean of financial development is 3.38. As shown in column 2, on average, a 50% undervaluation can increase the ratio of industrial output to GDP by 0.54 percentage points (50% $*$ [0.021–0.003 $*$ 3.38]). Given a 50% undervaluation, an additional 10% drop in the financial development index has the marginal effect of enlarging the industrial sector's share of the economy by 0.015 percentage points (50% $*$ 10% $*$ 0.003). As the mean value of the ratio of industrial output to GDP is 25% in our sample, the marginal effect is very significant.

Next, we test the effect of undervaluation on productivity in the tradable sector. As discussed earlier, when the borrowing constraint is binding, undervaluation can promote productivity in the tradable sector and this effect is more noticeable in

Table 4. **Endogeneity**
Dependent variable: economic growth rate ($growth_{ct}$)

	Difference GMM	**System GMM**
$\text{Growth}_{\text{c},t-1}$	0.018	0.038**
	(0.91)	(2.11)
Underval	0.013	0.037**
	(0.36)	(2.46)
Fin devt	0.053*	0.004
	(3.90)	(1.08)
Underval × fin devt	−0.003*	−0.017*
	(−0.23)	(−2.75)
$\text{Dependency ratio}_{t-1}$	−0.001***	−0.000*
	(−1.86)	(−2.67)
$\text{Trade openness}_{t-1}$	−0.028*	−0.009*
	(−5.38)	(−4.18)
$\text{Govt. expenditure share}_{t-1}$	−0.496*	−0.072*
	(−8.98)	(−4.97)
$\text{Investment share}_{t-1}$	0.247*	0.085*
	(5.60)	(5.51)
Fixed effects		
Economy fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Observations	3,529	1,889
AR(2)	0.101	0.187
Sargan	0.103	0.201

GMM = generalized moment method.
Notes:
1. t-statistics are in parenthesis.
2. Columns (1) and (2) report the results of difference GMM and system GMM, respectively.
3. Lagged periods are t-2 and t-3.
4. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc/data/pwt/

economies with less developed financial markets. One empirical challenge is that cross-economy data cannot be used to estimate productivity in the tradable sector of individual economies. Therefore, we turn to the relative productivity of the tradable and nontradable sectors. In fact, our model tells us undervaluation will only have an effect on productivity in the tradable sector. Consequently, if we can find a significant increase in relative productivity between the two sectors (with a more prominent result in economies with less developed financial markets), we can still identify the channel through which undervaluation promotes growth by generating a within-sector productivity increase.

Relative productivity between the two sectors is estimated as follows. First, relative nominal output is denoted as occurring in period t. Plugging this into

Table 5. **Channel I: Effect of Undervaluation on Expanding the Tradable Sector's Share of Gross Domestic Product**
Dependent variable: Share of industrial output in GDP

	(1)	**(2)**
Share of industrial output in GDP$_{t-1}$	0.795*	0.795*
	(76.56)	(76.55)
Underval	0.013*	0.021*
	(5.79)	(3.78)
Fin devt	−0.002***	−0.002***
	(−1.77)	(−1.92)
Underval × fin devt		−0.003*
		(−3.61)
Dependency ratio$_{t-1}$	−0.000*	−0.000*
	(−2.92)	(−3.11)
Trade openness$_{t-1}$	0.000	0.000
	(0.27)	(0.31)
Govt. expenditure share$_{t-1}$	−0.014***	−0.017**
	(−1.78)	(−2.08)
Investment share$_{t-1}$	0.021**	0.020**
	(2.53)	(2.41)
Fixed effects		
Economy fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Observations	3,338	3,338
R^2	0.681	0.682

GDP = gross domestic product.
Notes:
1. Observations are annual data for the period 1980–2011.
2. Both undervaluation and private credit/GDP are in logarithmic form.
3. t-statistics in parenthesis.
4. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc/data/pwt/

equation (11) results in

$$V_t^{TN} = \frac{P_t^T y_t^T}{P_t^N y_t^N} = \frac{P_t^T A_t^T}{P_t^N A_t^N} \frac{\left(\alpha^T S_t/\kappa \overline{S}\right)^{\frac{\alpha^T}{1-\alpha^T}}}{\left(\alpha^N/\kappa\right)^{\frac{\alpha^N}{1-\alpha^N}}}$$

Taking the log of both sides results in

$$\ln\left(\frac{A_t^T}{A_t^N}\right) = \ln V_t^{TN} - \ln\left(\frac{P_t^T}{P_t^N}\right) - \frac{\alpha^T}{1-\alpha^T}\ln\left(\frac{S_t}{\overline{S}}\right) - \frac{\alpha^T}{1-\alpha^T}\ln\left(\frac{\alpha^T}{\kappa}\right) - \frac{\alpha^N}{1-\alpha^N}\ln\left(\frac{\alpha^N}{\kappa}\right) \quad (18)$$

where both V_t^{TN} and S_t can be observed in the data. The last two terms on the right side of the equation are constant (allowing for differences across economies). What remains to be estimated is the relative price (P_t^T/P_t^N) at period t. Following Mao and Yao (2014), we assume the overall domestic price level at each period is the geometric mean of the price level in two sectors:[7]

$$P_t = \left(P_t^T\right)^{\theta} \left(P_t^N\right)^{1-\theta}$$

Based on the definition of purchasing power parity, we have

$$PPP = \left(\frac{P^{T*}}{P^T}\right)^{\theta} \left(\frac{P^{N*}}{P^N}\right)^{1-\theta} = \left(\frac{1}{S_t}\right)^{\theta} \left(\frac{P^{N*}}{P^N}\right)^{1-\theta}$$

For the simplicity of expression, the subscript t is omitted here. Rearranging the equation above results in

$$\ln\left(\frac{P^{N*}}{P^N}\right) = \frac{1}{1-\theta}\left(\ln PPP + \theta \ln S_t\right)$$

Plugging this into the identity $\ln\left(\frac{P^T}{P^N}\right) = \ln\left(\frac{P^T}{P^{T*}}\right) + \ln\left(\frac{P^{T*}}{P^{N*}}\right) + \ln\left(\frac{P^{N*}}{P^N}\right)$ results in

$$\ln\left(\frac{P^T}{P^N}\right) = \frac{1}{1-\theta}\left(\ln PPP + \ln S_t\right) + \ln\left(\frac{P^{T*}}{P^{N*}}\right)$$

Since the world relative price P^{T*}/P^{N*} between the two sectors is exogenous for a single economy, it can be absorbed into a time fixed effect. We estimate the relative price between the two sectors at period t as $P_{TN,t}$ in the specification below:

$$\ln P_{TN,t} = \gamma\left(\ln PPP_{ct} + \ln S_{ct}\right) + \delta_c + \delta_t + \varepsilon_{ct}$$

Plugging this into equation (18) results in

$$\ln A_{TN,ct} = \ln V_t^{TN} - \widehat{\ln V_t^{TN}}$$

where $A_{TN,ct}$ is the relative productivity between the tradable (T) and nontradable (N) sectors, which are replaced by the industrial (I) and service sector (S),

[7]This form can be derived from the utility function $U_t = \left(c_t^T\right)^{\theta}\left(c_t^N\right)^{1-\theta}$. The specific function form has a trivial impact on our estimation results since we only need a specification establishing the relationship between overall prices and sectorial prices.

Table 6. **Channel II: Effect of Undervaluation on Increasing the Relative Productivity of the Tradable Sector**

Relative productivity of tradable to nontradable sector	**(1)**	**(2)**
Relative productivity of tradable to nontradable sector$_{t-1}$	0.792*	0.791*
	(75.45)	(75.41)
Underval	0.081*	0.159*
	(6.47)	(5.01)
Fin devt	−0.018*	−0.020*
	(−2.69)	(−3.00)
Underval × fin devt		−0.028*
		(−2.69)
Dependency ratio$_{t-1}$	−0.001***	−0.001**
	(−1.72)	(−2.08)
Trade openness$_{t-1}$	0.005	0.006
	(0.83)	(0.91)
Govt. expenditure share$_{t-1}$	−0.089**	−0.113*
	(−2.06)	(−2.58)
Investment share$_{t-1}$	0.061	0.052
	(1.34)	(1.15)
Fixed effects		
Economy fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Observations	3,317	3,317
R^2	0.666	0.667

GDP = gross domestic product.
Notes:
1. Observations are annual data for the period 1980–2011.
2. Both undervaluation and private credit/GDP are in logarithmic form.
3. t-statistics are in parenthesis.
4. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc/data/pwt/

respectively. $\widehat{\ln V_t^{TN}}$ is estimated as

$$\ln V_t^{TN} = \delta_1 \ln PPP_{ct} + \delta_2 \ln S_{ct} + \delta_c + \delta_t + \varepsilon_{ct}$$

The effect of undervaluation on raising the relative productivity of the tradable sector compared with that of the nontradable sector is shown in Table 6. Such an effect is significant and is amplified in economies with less developed financial markets. Quantitatively, column (2) informs us that for economies with an average level of financial market maturity, a 50% undervaluation can lead to a relative productivity increase of 3.22 percentage points (50% $*$ [0.159–0.028 $*$ 3.38]), which is economically significant. In terms of the interactive effect, given a 50% undervaluation and a 10% decline in financial market development, relative productivity increases by an additional 0.14 percentage points (50% $*$ 10% $*$ 0.028).

V. Conclusion

We have tested our hypothesis using cross-economy data for the period 1980–2011 and the results support our predictions. For economies at the 25th percentile of financial development distribution, a 50% undervaluation can increase the economic growth rate by 0.3 percentage points. With a 10% decline in the financial development level, the stimulating effect of undervaluation is an additional 0.045 percentage points. Verifying the two channels included in our theoretical discussion, we find that for economies with an average level of financial market development a 50% undervaluation is associated with a 0.54 percentage point increase in the tradable sector's share of GDP. Meanwhile, the relative productivity of the tradable versus nontradable sector increases by 3.22 percentage points. Given a 10% decline in financial market development, the marginal effects of undervaluation on expanding the tradable sector's share of GDP and the relative productivity of the tradable sector are 0.015 and 0.14 percentage points, respectively.

These findings have substantial policy implications in that they offer a deeper understanding of why policy makers in many developing economies favor an undervalued exchange rate and the related export-oriented development strategies. According to our results, undervaluation will lead to relaxed borrowing constraints in the tradable sector, which will facilitate increased industrial output (as a % of GDP) and an accelerating technological growth rate in the tradable sector. Both of these channels can boost economic growth, with the impacts being more prominent in economies with less developed financial markets. If we take the technological spillover effects into consideration, the growth effect is further magnified. Since developing economies are typically characterized as having underdeveloped finance sectors and tighter borrowing constraints, their likelihood of adopting an undervaluation policy will consequently be higher.

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*ADB recognizes "China" as the People's Republic of China.

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Determinants of Intra-ASEAN Migration

Michele Tuccio*

International labor mobility in Southeast Asia has risen drastically in recent decades and is expected to continue increasing with the establishment of the Association of Southeast Asian Nations (ASEAN) Economic Community in 2015. This paper looks at the determinants of the movement of workers and finds three structural factors that will likely drive further intra-ASEAN migration in the coming years: (i) demographic transition, (ii) large income differentials between economies, and (iii) the porosity of borders. A microfounded gravity model is estimated in order to empirically analyze the main determinants of intra-ASEAN migration in the period 1960–2000. Results suggest that the movement of migrants between Southeast Asian economies has mostly been driven by higher wages and migrant social networks in destination economies, as well as natural disasters in origin economies.

Keywords: ASEAN, determinants, international migration, push and pull factors
JEL codes: F22, J61, O15, 053

I. Introduction

In recent decades, international labor mobility has played a prominent role in shaping the socioeconomic landscape of East Asian economies. Since the 1980s, high-performing economies in the Association of Southeast Asian Nations (ASEAN) have attracted a growing diaspora of foreign workers from neighboring economies at earlier stages of their development transition (Athukorala 2006). Intra-ASEAN migration skyrocketed from 1.5 million to 6.5 million migrants between 1990 and 2013, representing almost 70% of ASEAN's total migration at the end of the review period (ILO 2014).

The magnitude of intra-ASEAN migration is expected to increase as the ASEAN Economic Community, which was launched in 2015, seeks not only a more integrated regional economic strategy, but also the free mobility of professionals and skilled workers within the region. As ASEAN member states enter this new integration era from very different economic starting points, the freer flow of goods and capital is likely to accelerate the movement of low-skilled workers. Firms in higher-income economies with better access to infrastructure will raise their competitiveness vis-à-vis producers in lower-income economies, thereby increasing

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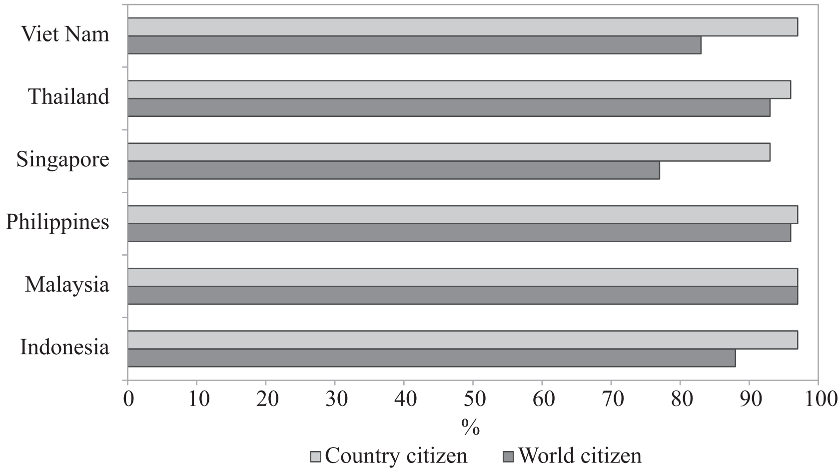
Figure 1. **Share of Individuals Who Identify as Citizens of Their Country of Origin and as Citizens of the World**



Source: World Values Survey. 2014. "World Value Survey Wave 5 and Wave 6." http://www.worldvaluessurvey.org

the benefits of migration to such markets (Martin and Abella 2014). Moreover, economic differentiation across the region is progressively manifested in a mix of skill shortages and surpluses among neighboring economies, which increases the economic benefits of international mobility (Manning and Sidorenko 2007).[1]

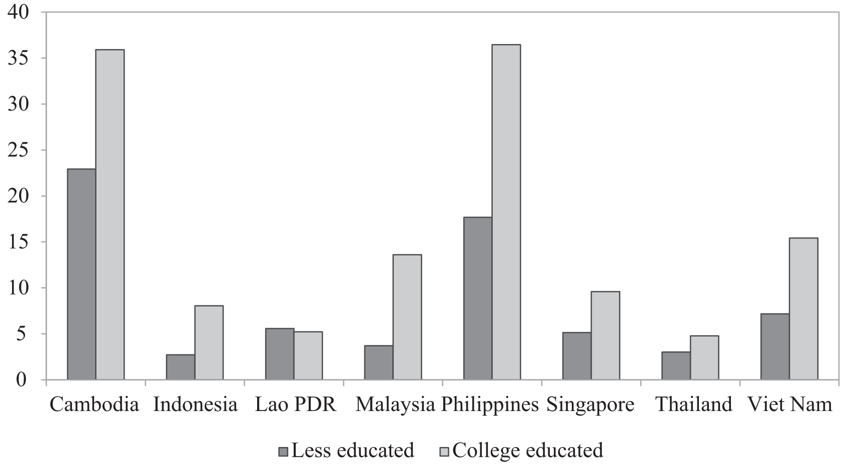
The rise in international migration in East Asia also reflects an increasing trend in internationalization and cosmopolitanism, with more and more people identifying as citizens of the world with global rather than national ties (Nejatbakhsh 2014). Recent data from the World Values Survey suggest that the share of people who identify as citizens of the world has almost converged with the proportion of individuals who see themselves as citizens of their country of origin (Figure 1).[2] Among those ASEAN economies participating in the survey, a remarkable 89% of the population on average expressed that they considered themselves to be citizens of the world, a figure that reached as high as 96% and 97% of respondents in the Philippines and Malaysia, respectively.

This growing sense of multiculturalism and cosmopolitanism within ASEAN is reflected in the increasing desire to migrate that has been observed in recent years at the global level. Clemens (2011) found that over 40% of the adults in the

[1] A predecessor of the ASEAN Economic Community is the 2002 ASEAN Tourism Agreement, which, among other things, introduced visa-free travel between ASEAN member states (Wong, Mistilis, and Dwyer 2011). This policy has led to the increased movement of workers across ASEAN economies. Facilitated by the removal of restrictions on tourist travel, workers have often overstayed in destination economies while working in the informal economy.

[2] Statistics provided in this paper are available for either the full set or selected subsets of ASEAN economies included in each database.

Figure 2. **Desired Migration Rates of College-Educated and Less-Educated Individuals by Economy of Origin**



Lao PDR = Lao People's Democratic Republic.
Source: Docquier, Frederic, Giovanni Peri, and Ilse Ruyssen. 2014. "The Cross-Economy Determinants of Potential and Actual Migration." *International Migration Review* 48 (s1): S37–S99.

world's poorest quartile of economies would like to migrate if the opportunity arose. Docquier, Peri, and Ruyssen (2014) used Gallup World Poll data to identify the percentage of people in a number of economies willing to emigrate abroad if given the chance. The results reported in Figure 2 suggest that on average more than 12% of ASEAN's population over the age of 25 years old wanted to migrate in 2010.[3]

Using aggregate data from Gallup surveys for 154 economies for 2010–2012, Esipova, Ray, and Pugliese (2011) construct a Potential Net Migration Index to measure the number of adults who would like to move permanently out of an economy minus the estimated number who say they would like to move into the same economy as a proportion of the total adult population. They found that the only ASEAN economies where the net flows of migration would be positive are Singapore and Malaysia. If all individuals who aspire to move either to or from Singapore and Malaysia did so, their adult populations would increase by about 129% and 12%, respectively. The numbers of people aspiring to move in and out of Thailand would roughly balance each other out, while for the remaining ASEAN economies, unimpeded international migration would likely reduce the adult population. In particular, if all individuals wishing to migrate in and out of an economy were able

[3]There is, however, great heterogeneity across economies and education levels. College-educated individuals are twice as likely to aspire to emigrate because of the (eventual) greater payoff of moving abroad. While Indonesians and Thais have relatively lower aspirations to emigrate than those in other ASEAN economies, almost 40% of high-skilled Cambodians and Filipinos are willing to engage in cross-border migration. In the case of the Philippines, the desire to emigrate is highest among people aged 15–34 years old, residents of urban areas, and more educated individuals (McKenzie, Theoharides, and Yang 2014).

to do so, the adult population would decline by about 31% in Cambodia, 14% in the Philippines, 9% in the Lao People's Democratic Republic (Lao PDR), and 5% each in Myanmar and Viet Nam (Esipova, Ray, and Pugliese 2014).

What is behind these large (actual and potential) movements of people? What are the determinants of international migration within ASEAN? There is need for a better understanding of the drivers of intra-ASEAN migration as labor mobility increasingly impacts Asian economies. This paper aims to tackle these critical issues by reviewing the existing literature on international migration in ASEAN and providing new insights through the analysis of data. In addition, a microfounded gravity model is borrowed from the trade literature and adapted to estimate the main push and pull factors driving cross-border migration flows.

Our findings suggest that large income and demographic differentials between ASEAN economies are likely to continue sustaining high levels of labor mobility in the years ahead. In addition, the porous borders that separate ASEAN member states might also contribute to boosting low-skilled, undocumented migration.

The remainder of the paper is structured as follows. Section II presents the linkages between individual characteristics and migration decisions. A set of structural factors that are likely to sustain intra-ASEAN migration flows is discussed in section III. Section IV introduces the specific characteristics of sending and receiving economies as key determinants. A gravity model for migration is introduced in section V and its econometric results are presented in section VI. Section VII concludes.

II. Migration Decisions and Individual Characteristics

A migrant's decision to move is influenced by both supply and demand factors. Economic and noneconomic incentives shape the supply side of international migration, encouraging individuals to engage in cross-border movements. Conversely, the need of immigrants in the destination economy as well as the immigration policies in place represent the demand side. An individual would therefore choose to migrate if the expected utility of living abroad is greater than the payoff of staying in the home economy (net of migration costs).

Individual characteristics, such as education and sex, influence both the supply and demand sides of migration. Consider a representative individual h facing the choice between staying in her home economy i or moving to a foreign economy j. The differential between wages at destination (w_j) and wages at origin (w_i) would be one of the main push factors affecting the probability of individual h to emigrate. Similarly, the unemployment rate at the destination affects the probability of finding a job after migrating. However, in both the origin and destination economies wages and unemployment rates are a function of the individual skill level (s_h) and gender (g_h). Hence, women and men, as well as low-skilled and high-skilled individuals, have different propensities to migrate based on their personal characteristics.

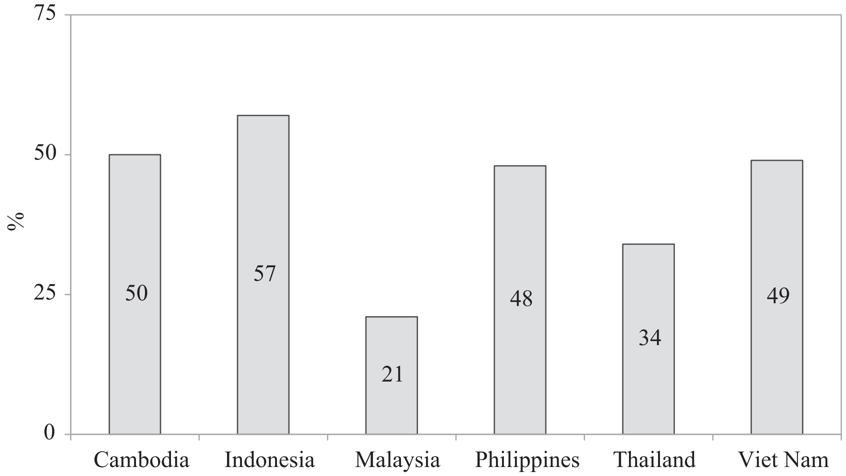
Labor markets in different destinations also need different types of foreign workers. For example, most destination economies have gender-segregated labor markets, with migrant women concentrated in domestic and caregiving work and men in construction, agriculture, and trade. Since the second half of the 20th century, there has been an increasing trend of female migrants from economies such as the Philippines, Indonesia, and (more recently) Myanmar to ASEAN's fastest-growing economies of Singapore and Malaysia (Cortes and Pan 2013). With regard to female migration in the last few years, both sending and receiving economies have seen shifting patterns due to changes in the balance of power between ASEAN member states. Destination economies often grant temporary visas for women to work as domestic helpers because of the increasing number of women earning wages in the formal sector (Yeoh, Huang, and Gonzales III 1999). The magnitude of these flows is massive. For example, each year around 100,000 women emigrate from the Philippines to work as domestic helpers and caregivers (Cortes and Pan 2013), while in Singapore in 2000 there was one foreign maid in every eight households (Yeoh, Huang, and Gonzales III 1999).

This paper uses several microlevel surveys from ASEAN economies to estimate the proportion of women among current emigrants (Figure 3).[4] Interestingly, more than half of all emigrants from Indonesia are female and approximately half of all emigrants from Cambodia and the Philippines are women. As argued by Lim and Oishi (1996), there are several distinctive features of the East Asian economic landscape that can help explain the recent feminization of migration flows. First, the supply of East Asian female migrants has been very flexible relative to men in East Asia and women in other regions of the world. East Asian women have responded rapidly to changing demand in foreign labor markets, which is partly due to low levels of discriminatory gender norms and high female labor force participation rates in their home economies. Second, ASEAN economies have seen the rise of a large immigration industry that facilitates both legal and undocumented female migration. Third, women, especially young women, are more likely than men to rely on informal social networks and chain migration, following their relatives or friends who are already employed abroad. The steady enlargement of the diasporas of Cambodians, Filipinos, and Indonesians in host economies has the effect of encouraging other women to follow.

In a similar way, the educational attainment of migrants can partly explain bilateral international migration flows. The positive or negative selection of migrants is, on one hand, due to self-selection mechanisms, and, on the other hand, due to skill-selective immigration policies in place in destination economies (Docquier and Machado 2016). In a macro perspective, economies of origin frequently specialize

[4]These surveys include the Cambodia Socioeconomic Survey (2012), Indonesia Family Life Survey (2007), Malaysia Labor Force Survey (2010), Philippines Labor Force Survey (July 2010), Thailand Socioeconomic Survey (2009), and Viet Nam Household Living Standard Survey (2012).

Figure 3. **Share of Women among Current Working-Age Emigrants by Economy of Origin**



Sources: Cambodia National Institute of Statistics. 2012. "Cambodia Socio-Economic Survey." International Labour Organization. http://www.ilo.org/surveydata/index.php/catalog/341; RAND. 2007. "Indonesia Family Life Survey 2007." http://www.rand.org/labor/FLS/IFLS.html; Department of Statistics. 2010. "Labor Force Survey." Government of Malaysia. https://www.statistics.gov.my/index.php?r=column/ctheme&menu_id=U3VPMldoYUxzVzFaYmNkWXZteGduZz09&bul_id=NHUxTlk1czVzMGYwS29mOEc5NUtOQT09; Philippines Statistical Authority. 2010. "Labor Force Survey 2010." https://psa.gov.ph/statistics/survey/labor-force/lfs/2010; National Statistical Office. 2009. "Thailand Household Socio-Economic Survey 2009." Ministry of Information and Communications Technology. http://catalog.ihsn.org/index.php/catalog/1486; General Statistics Office. 2012. "Household Living Standard Survey 2012." Government of Viet Nam. http://www.gso.gov.vn/default_en.aspx?tabid=483&idmid=4&ItemID=13888

in supplying migrants with a specific skill, while labor markets in host economies often require different skills or levels of education. For example, although Singapore has typically adopted a two-pronged policy for less-skilled and professional migrant workers, the government's willingness to recruit high-skilled migrants has recently resulted in a reduction in work permits for the less skilled and a corresponding increase in the share of permits for foreign professionals (Yap 2014).

By looking at the differences in educational attainment between emigrants and natives by economy of origin, Figure 4 confirms the heterogeneous skill patterns of ASEAN emigrants.[5] Almost two-thirds of migrants from the Philippines hold a tertiary degree, while on average less than one-third of the general population is a university graduate. This positive selection of migrants is in part due to the fact that most Filipino workers migrate to Organisation for Economic Co-operation and Development economies, which require higher educational levels, and in part due to a specific government strategy. As discussed by Tullao, Conchada, and Rivera (2014), the Government of the Philippines encourages university graduates

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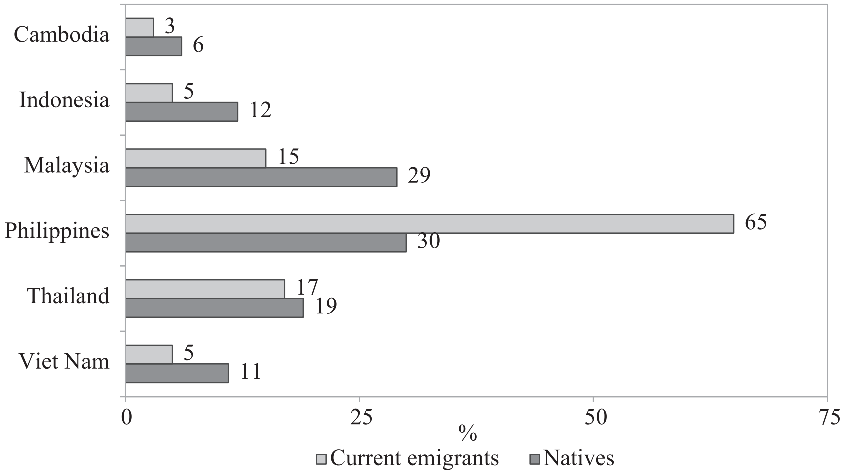
[5]In line with previous literature, we assume that migrants' skills can be at least partially captured by their level of educational attainment. Cross-economy and/or economy-level information on the real skill levels of workers are currently not available for most economies. Among others, Beine, Bertoli, and Fernández-Huertas Moraga (2015) and McKenzie and Rapoport (2010) adopt a similar approach and we refer to them for further discussion on the issue.

Figure 4. **Share of Working-Age Population with a University Degree by Economy of Origin**



Sources: Cambodia National Institute of Statistics. 2012. "Cambodia Socio-Economic Survey." International Labour Organization. http://www.ilo.org/surveydata/index.php/catalog/341; RAND. 2007. "Indonesia Family Life Survey 2007." http://www.rand.org/labor/FLS/IFLS.html; Department of Statistics. 2010. "Labor Force Survey." Government of Malaysia. https://www.statistics.gov.my/index.php?r=column/ctheme&menu_id=U3VPMldoYUxzVzFaYmNkWXZteGduZz09&bul_id=NHUxTlk1czVzMGYwS29mOEc5NUtOQT09; Philippines Statistical Authority. 2010. "Labor Force Survey 2010." https://psa.gov.ph/statistics/survey/labor-force/lfs/2010; National Statistical Office. 2009. "Thailand Household Socio-Economic Survey 2009." Ministry of Information and Communications Technology. http://catalog.ihsn.org/index.php/catalog/1486; General Statistics Office. 2012. "Household Living Standard Survey 2012." Government of Viet Nam. http://www.gso.gov.vn/default_en.aspx?tabid=483&idmid=4&ItemID=13888

to meet international standards by improving the quality of their education through certification measures, often in partnership with destination economies such as Canada.

Conversely, Thailand resorts to labor immigration to meet industry needs, especially for lower-skilled jobs (ADBI, ILO, and OECD 2014). This partly explains why Cambodian emigrants, who typically migrate to Thailand, appear to be negatively selected. Similarly, despite a gradual improvement in educational attainment in recent decades, Indonesian emigrants appear to be mostly unskilled and employed in the agriculture, transportation, and housekeeping sectors (Kuncoro, Damayanti, and Isfandiarni 2014).

III. Structural Determinants of Intra-ASEAN Migration

Although individual characteristics help us better understand international migration flows, not all individuals with certain characteristics decide to migrate; and even among emigrants, not everybody chooses the same destination. Some migration corridors are nearly empty while others experience large bidirectional flows. Typically, the major origin economies in ASEAN are Indonesia, Myanmar, and Viet Nam, which all have relatively lower income levels. Conversely, Malaysia,

Table 1a. **Major Migration Corridors in ASEAN, 2000–2010**

Rank	Origin Economy	Destination Economy	Migration Flows
1	Indonesia	Malaysia	543,238
2	Malaysia	Singapore	225,661
3	Myanmar	Thailand	201,417
4	Myanmar	Malaysia	79,176
5	Viet Nam	Cambodia	43,857
6	Thailand	Cambodia	36,048
7	Viet Nam	Malaysia	35,317
8	Lao PDR	Thailand	31,721
9	Indonesia	Singapore	21,772
10	Viet Nam	Thailand	14,439

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.
Source: Özden, Çağlar et al. 2011. "Where on Earth Is Everybody? The Evolution of Global Bilateral Migration 1960–2000." *The World Bank Economic Review* 25 (1): 12–56.

Table 1b. **Major Migration Diasporas in ASEAN, 2010**

Rank	Origin Economy	Destination Economy	Migration Stocks
1	Indonesia	Malaysia	1,316,973
2	Malaysia	Singapore	842,899
3	Myanmar	Thailand	637,383
4	Viet Nam	Cambodia	148,516
5	Thailand	Cambodia	122,071
6	Lao PDR	Thailand	100,380
7	Myanmar	Malaysia	99,718
8	Viet Nam	Malaysia	93,215
9	Indonesia	Singapore	81,324
10	Singapore	Malaysia	61,993

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.
Source: Özden, Çağlar et al. 2011. "Where on Earth Is Everybody? The Evolution of Global Bilateral Migration 1960–2000." *The World Bank Economic Review* 25 (1): 12–56.

Singapore, and Thailand have absorbed most intra-ASEAN migration in recent years, given their need for workers to fill fast-growing labor markets (Tables 1a and 1b).[6] According to Martin (2007), foreigners constituted about 5% of the Thai workforce in 2007 and about 10% of the working-age population in Malaysia in 2010 (Del Carpio et al. 2015). At the top-end of the distribution lies Singapore, which represents an extreme case of labor markets in which one of every three employed persons was a foreigner in 2014 (Ministry of Manpower 2015).

[6]Tables 1a and 1b are based on the World Bank's Global Migration Database, which is a comprehensive collection of data on the stock of international migrants by country of birth and citizenship, as enumerated by population censuses, population registers, nationally representative surveys, and other official statistical sources. By definition, illegal migration is not fully taken into account in such a database. Hence, important migration routes for undocumented foreign workers may not be reported.

In addition to individual characteristics, three main structural factors appear to be driving labor migration in ASEAN: (i) the demographic transition underway in most East Asian economies that affects the supply and demand of labor, producing additional migration opportunities and challenges; (ii) income differentials between economies, which eventually represent the greatest pull forces for migrants; (iii) the penetrability of porous borders, which can explain the high prevalence of undocumented migration in some ASEAN economies.

Much of East Asia's economic expansion in recent decades is linked to the region's demographic changes (Bloom and Finlay 2009). Since the aftermath of the Second World War, "Asia has exploited the catch-up potential with such enthusiasm that it has produced one of the fastest and most dramatic demographic transitions ever" (Bloom and Williamson 1998, 424). A sharp decline in child mortality rates has been accompanied by an increase in life expectancy and a rapid decrease in total fertility rates over the years. As a result, all ASEAN economies saw an increase in the size of their working-age population between 1965 and 2010, which further fueled already swift economic development.

We adopt a Shapley decomposition approach to quantify the extent to which aggregate economic growth in ASEAN member states has been linked to changes in the employment rate, productivity, and the demographic dividend over the last 2 decades. This technique allows for describing changes in per capita value added through the growth in each of its components (see Gutierrez et al. 2009 for a careful explanation of the methodology).[7] Using data from the ILO and the World Bank for the period 1990–2010, we find that demographic change accounted for almost one-fifth of total income growth in ASEAN member states over the last 2 decades (Figure 5).[8] In some economies, such as Singapore and Indonesia, the increase in the share of the working-age population has been even more pronounced (Ahsan et al. 2014).

However, things are changing in East Asia. The favorable demographics that have been contributing to rapid economic growth for the past 50 years are quickly shifting. ASEAN's population is becoming older as average life expectancy increases and fertility rates decline, which will eventually lead to a contraction in relative size of the working-age population. Projections for the next 3–4 decades show labor forces in several economies shrinking dramatically, which will pose important challenges to sustaining economic growth (ILO 2014). In addition, the dependent population in the future will mainly comprise the elderly, which will

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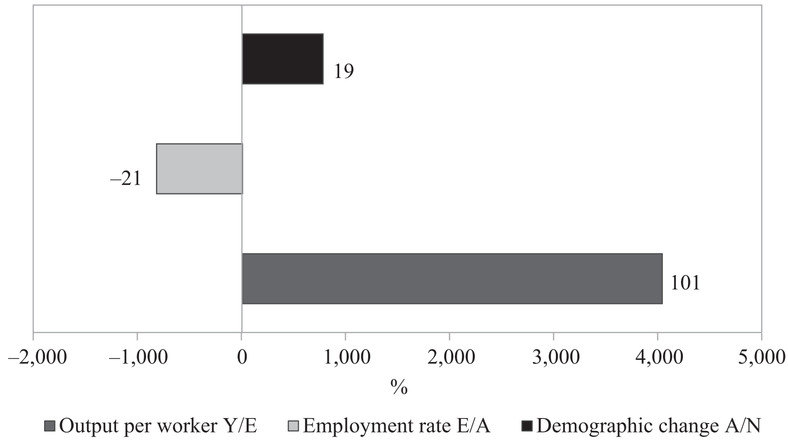
[7]Following the Shapley decomposition method, gross domestic product per capita y (aggregate value added Y divided by the total population N) can be written as $y = \frac{Y}{N} = \frac{Y}{E}\frac{E}{A}\frac{A}{N}$, where E is total employment, A is the working-age population, and N is the total population. Such a relationship can be also written as $\bar{y} = \bar{\omega} + \bar{e} + \bar{a}$, where $\bar{\omega}$ refers to changes in output per worker, $\bar{e}$ captures changes in the employed share of the working-age population, and $\bar{a}$ is the demographic change.

[8]Per capita value added comes from the World Bank's World Development Indicators and its change has been calculated as the growth rate between 1990 and 2010. Similarly, the working-age population (World Development Indicators) and the total number of employed people (ILOSTAT) are exploited to calculate changes over 2 decades.

Figure 5. **Aggregate Productivity, Employment, and Demographic Profile of Growth in ASEAN, 1990–2010**



A = working-age population, ASEAN = Association of Southeast Asian Nations, E = total employment, N = total population, and Y = value added.
Source: World Bank. 2016. "World Development Indicators." http://data.worldbank.org/data-catalog/world-development-indicators

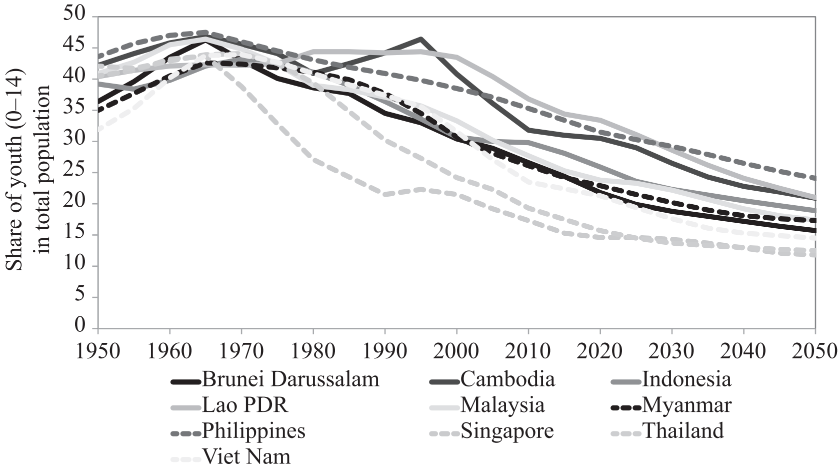
increase the fiscal burden of member states and crowd out investments (Ahsan et al. 2014).

At the same time, a critical heterogeneity exists among ASEAN economies. The labor forces in Cambodia, Indonesia, the Lao PDR, and the Philippines will be powered by expanding pools of youth through 2050 (Figure 6). Singapore, Thailand, and Viet Nam are expected to have much greater dependency rates by then, with an over-65 population that will reach almost one-third of Thailand's total population in 2050 (Figure 7). As mentioned above, the population aging process is due to a mix of rising life expectancy and declining fertility rates. In the relatively higher-income economies of the region such as Singapore and Thailand, the fertility rates have fallen as low as 1.2 and 1.6, respectively, which represent some of the lowest fertility rates in the world (Özden and Testaverde 2015). Large imbalances in the age composition of the population across economies are likely to produce shortages of workers in certain economies and an abundance in other.

It appears that international migration within East Asia can serve as a relief mechanism to address demographic challenges. Given the geographic proximity to one another of economies with either older or younger populations, intra-ASEAN migration can ameliorate labor shortages in economies such as Thailand and Singapore while providing migrants from labor-abundant economies new job opportunities abroad. In sum, demographic changes have been and will continue to be one of the principal determinants of international migration in ASEAN.

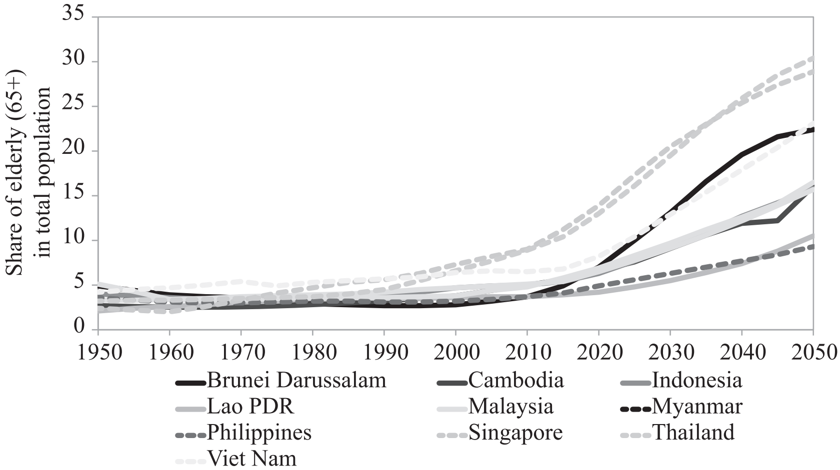
The large income and wage differentials between economies are a second structural factor behind the rise of intra-ASEAN migration (World Bank 2014). In

Figure 6. **Share of Youth (0–14 Years) in the Total Population**



Lao PDR = Lao People's Democratic Republic.
Source: United Nations Department of Economic and Social Affairs. 2013. *World Population Prospects: The 2012 Revision*. New York: United Nations.

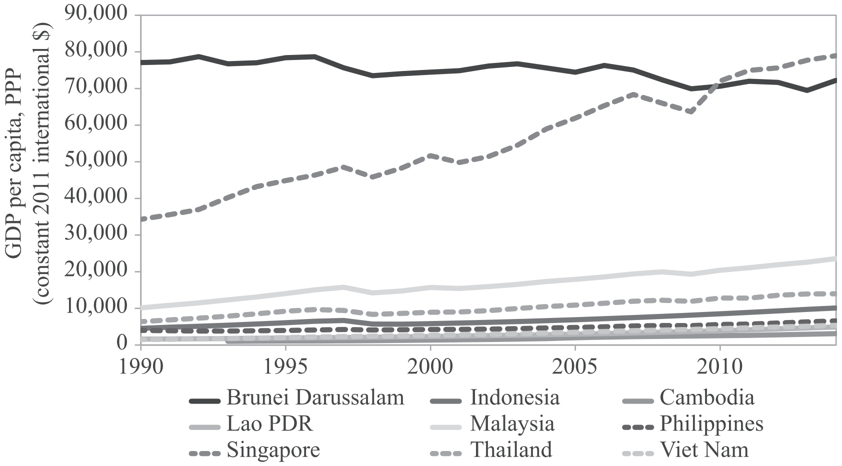
Figure 7. **Share of Elderly (65+ Years) in the Total Population**



Lao PDR = Lao People's Democratic Republic.
Source: United Nations Department of Economic and Social Affairs. 2013. *World Population Prospects: The 2012 Revision*. New York: United Nations.

fact, although the average gross domestic product (GDP) per capita in ASEAN was just above $24,000 in 2014 (constant 2011 international dollars at purchasing power parity), there is a great deal of variability within the region, with average incomes

Figure 8. **Income Differentials across ASEAN Economies**



ASEAN = Association of Southeast Asian Nations, GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, PPP = purchasing power parity.
Source: World Bank. "World Development Indicators." http://data.worldbank.org/data-catalog/world-development-indicators

as low as $3,093 in Cambodia and as high as $78,958 in Singapore (ILO 2014). The contrast is also striking if we look at average monthly wages, which range from $119 (constant 2005 prices at purchasing power parity) in the Lao PDR to $3,547 in Singapore in 2013 (ILO 2014). In addition, wages in Thailand are three times higher than in Cambodia, while wages in Malaysia are approximately three and a half times those in Indonesia.

Figure 8 shows the differences in GDP per capita within ASEAN. The relatively higher-income economies of Brunei Darussalam, Malaysia, Singapore, and Thailand (dashed lines) are all labor-receiving economies, while the relatively lower-income economies (solid lines) of Cambodia, Indonesia, the Lao PDR, the Philippines, and Viet Nam are labor-sending economies. Since potential migrants aim at maximizing their expected utility by moving abroad, they tend to move to destinations where they can improve their income and wealth. As a consequence, the large wage and unemployment differentials among ASEAN economies are likely to sustain large intraregional migration flows up to a point in the future when wages and employment rates converge across economies.

A third factor unique to intra-ASEAN migration is the porosity of its borders (Chia 2006). Facilitated by weak border controls, irregular migration has become an important feature of ASEAN labor mobility (Pempel 2006). The archipelagic structure of a portion of the region with dispersed maritime borders facilitates the undocumented movement of people (Tan and Ramakrishna 2004). The length of shared borders across remote mountainous areas makes it difficult to control and limit the inflow of illegal labor in other parts of the region (Bain 1998). In addition, irregular migration not only refers to those trespassing across borders without the required documents, but also includes those who overstay on tourist visas, students engaged in employment, regular migrants continuing beyond the contract period, and individuals trafficked in the sex industry (Wickramasekera 2002).

Given its very nature, quantifying the extent of irregular migration is a hard task. However, available estimates suggest that between 500,000 and 750,000 illegal migrants were residing in Thailand in 2000, mostly from neighboring Cambodia, the Lao PDR, and Myanmar. Indonesians and Filipinos represented the vast majority of the 1 million illegal migrants estimated to live in Malaysia in 1998 (Manning 2002).

Historically, irregular migration has been firstly tolerated and then sanctioned by ASEAN governments (Battistella and Asis 1998). Despite the measures put in place, illegal migration continues to be a recurrent feature of ASEAN economies. An emergency ASEAN ministerial meeting was assembled in 2015 to strengthen cooperation in the fight against irregular migration and human trafficking (ASEAN 2015).

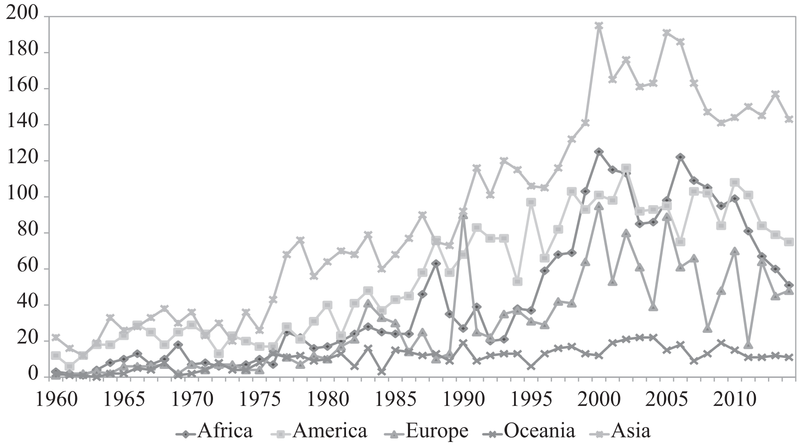
Among the reasons for the pervasive presence of undocumented migrants in ASEAN, restrictive immigration policies that are often in contrast with labor market needs in rapidly expanding destination economies play a key role (Abella 2000). At the same time, extreme poverty and unemployment can push individuals to look for opportunities elsewhere. Political instability and repressive policies toward ethnic minorities can also encourage mobility (Wickramasekera 2002). Furthermore, the high costs of legal recruitment and the restrictive terms and conditions of employment contracts in some economies such as Malaysia have led to resistance among both employers and workers against the legal employment process for foreign workers (Kassim 2002).

IV. The Role of Specific Features of Sending and Receiving Economies

The unique characteristics of both origin and destination economies are also important drivers of international migration in ASEAN. Among the features of origin economies that may lead individuals to engage in cross-border migration, political instability, and civil conflicts can partially explain emigration from Myanmar in recent decades. Ongoing developments are expected to shape future migration patterns, with Myanmar's political transition potentially leading to the eventual reversal of some of these previous flows (World Bank 2012).

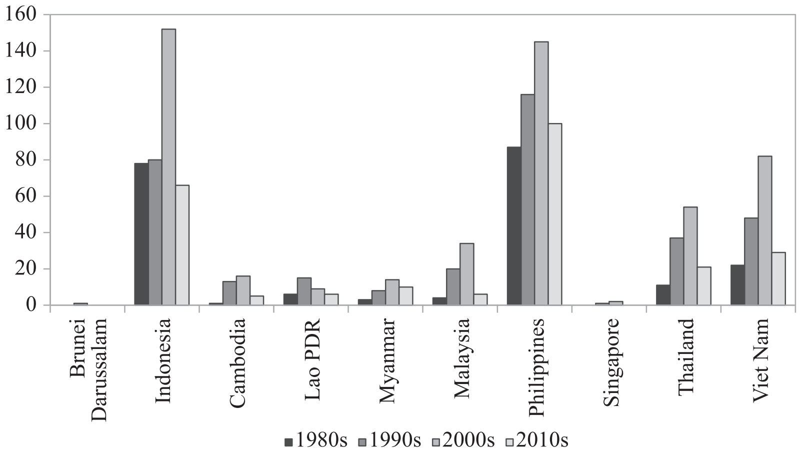
Natural disasters and weather instabilities are also particularly relevant in the Asian context. Asia was affected by nearly half of all natural disasters between 1990 and 1999, accounting for up to 70% of all lives lost (United Nations International Strategy for Disaster Reduction 2004). Since the start of systematic reporting of disasters in the 1960s, the number of calamities reported worldwide has been steadily growing, while Asia still appears to be the continent most affected by natural

Figure 9a. **Incidence of Natural Disasters by Continent, 1960–2014**



Source: Centre for Research on the Epidemiology of Disasters. "EM-DAT: International Disaster Database." http://www.emdat.be/database

Figure 9b. **Incidence of Natural Disasters in ASEAN, 1960–2014**



ASEAN = Association of Southeast Asian Nations.
Source: Centre for Research on the Epidemiology of Disasters. "EM-DAT: International Disaster Database." http://www.emdat.be/database

disasters—such as earthquakes, floods, volcanic eruptions, and hurricanes—with almost 200 disasters in 2000 alone (Figure 9a). Indonesia, the Philippines, Thailand, and Viet Nam appear to be the most frequently affected economies, while Brunei Darussalam, Cambodia, Malaysia, and Singapore are the least affected (Figure 9b).

Natural disasters can force people out of their homes before or immediately after an event due to the unforeseeable nature of most calamities. The impacts on the socioeconomic conditions of forced migrants often create a vicious circle, with poorer individuals being less able to cope with a disaster and ending up more vulnerable than before. Asian economies also suffer disproportionately from climate instability, while the persistence of natural disasters in certain areas can impede development given the continuous need to overcome the impacts of such calamities (Naik, Stigter, and Laczko 2007).

Lastly, migration costs need to be taken into account in the analysis of the main determinants of intra-ASEAN migration. The relative gain a migrant achieves by moving abroad also depends on the physical and social distance between her home economy and the destination economy (Fafchamps and Shilpi 2013). Greater geographic distance between the two economies implies higher travel costs for the initial move as well as for visits back home. In addition, the further away the origin and destination economies are from one another, the more costly it is to acquire information ex ante about the foreign labor market (Mayda 2010).

For this reason, social networks play a key role in lowering migration costs and facilitating flows by correcting for the asymmetry of information that potential migrants face (Munshi 2003, Beaman 2012). In recent decades, international migrants in Asia have relied on their networks of social capital abroad in choosing destinations (Hugo 2005). Social networks not only ease mobility but also help migrants in adjusting to and integrating with socioeconomic conditions in the receiving economy.

V. Gravity Model Analysis of Intra-ASEAN Migration

A. Methodology

As discussed in the previous sections, the choice of the optimal location for migration is given by the comparison between the utility associated with each location: an individual will choose to live where the payoff is greatest, net of any migration costs. The bilateral migration rate between two economies is thus a function of the following:

$$\textit{migration rate} = f(\textit{income differential}, \textit{migration costs})$$

In particular, migration flows are driven by the income and wage differentials between the economy of destination j and the economy of origin i, $(w_{j,t}/w_{i,t})$, as well as the physical distance between the two economies ($dist_{ij}$). Whether the economies share a common border ($cont_{ij}$) also influences the likelihood of bilateral migration, especially in ASEAN where borders are porous and less monitored. Finally, social networks, proxied by the lagged stock of migrants from economy i in economy j ($network_{ij,t-1}$), also affect mobility by lowering the monetary and psychological costs of migrating.

To empirically estimate the impact of the aforementioned drivers on bilateral migration flows within ASEAN, we adopt a gravity model approach. Borrowed from the trade literature, the gravity model specifies trade as a positive function of the attractive mass of two economies and a negative function of distance between them (Lewer and Van der Berg 2008). Since migration is also driven by push and pull factors, we adjust this framework in order to encompass migration flows.

Following Beine and Parsons (2015), our dependent variable is the number of migrants from economy i in economy j as a ratio of natives from i who have chosen not to migrate. Formally, let $N_{i,t}$ be the native population in economy i at time t. At each point in time, natives choose their optimal location among a set of possible foreign destinations and their own home economy. Let $N_{ij,t}$ be the size of the native population of economy i moving to the optimal destination j and let $N_{ii,t}$ be the size of the native population of economy i deciding to stay in their home economy i. The bilateral migration rate between i and j is thus given by $N_{ij,t}/N_{ii,t}$.

B. Data

In order to compute $N_{ij,t}$, we exploit the World Bank's Global Migration Database, which includes bilateral migration data for 226 economies over the period 1960–2000 (see Özden et al. 2011 for a detailed description of the data set). Since information is provided on migration stocks for each decade, we compute migration flows from origin economy i to destination economy j as the difference in migration stocks between two contiguous decades:[9]

$$N_{ij,t} = stock_{ij,t} - stock_{ij,t-1}$$

To recover $N_{ii,t}$ (the native population choosing not to migrate), we subtract from the United Nations' *World Population Prospects* data the total number of immigrants in origin economy i, which in turn is calculated from the migration data as $\sum_{j=1}^{J} stock_{ji,t}$. Our main specification will therefore be

$$\ln\left(\frac{N_{ij,t}}{N_{ii,t}}\right) = \alpha_0 + \alpha_1 \ln\left(\frac{w_{j,t}}{w_{i,t}}\right) + \alpha_2 \ln\left(dist_{ij}\right) + \alpha_3 cont_{ij} + \alpha_4 \ln\left(network_{ij,t-1}\right) + \gamma_i + \gamma_j + \gamma_t + \varepsilon_{ij,t}$$

where time-invariant characteristics of the origin and destination economies are captured by γ_i and γ_j, respectively, and time fixed effects are γ_t. Income differential is measured as the ratio between destination and origin economy per capita GDP.

[9]This second-best procedure will unavoidably result in negative flows as well (migration stocks declining over time). This may be due to migrants returning home, moving to a third economy, or dying. Thus, in constructing this measure, we assume that both deaths and return migration are small relative to net flows and we set negative flows equal to 0 (Beine, Bertoli, and Fernández-Huertas Moraga 2015). As argued by Beine, Docquier, and Özden (2011), even though this procedure may be suboptimal, it provides a fairly accurate picture of migratory movements during the period and it has become the standard approach in cross-economy studies on international migration (see Bertoli and Fernández-Huertas Moraga 2015, Beine and Parsons 2015, and Maurel and Tuccio 2016, among others).

Data are taken from the version 8.1 of the Penn World Table (Feenstra, Inklaar, and Timmer 2015).[10] Distance (bilateral distance between the largest city in each of the two economies weighted by the population share of each city in the economy's total population) and contiguity (a dummy variable equal to 1 if the origin and destination economies share a common border) are taken from the CEPII's Gravity Dataset (Head, Mayer, and Ries 2010). Social networks are included to account for diaspora effects and they are measured as the stock of migrants from origin economy i in destination economy j at the beginning of the decade (data from the World Bank's Global Migration Database).

In addition, we augment the above specification by including the share of economy i's population aged 15–29 years $\left(youth_{i,t}\right)$ in order to capture demographic push factors in the origin economy (Mayda 2010). A larger share of youth at the origin implies more new entrants in the labor market at time t, thereby reducing employment opportunities at home and increasing the payoff of moving abroad in search of employment. The youth bulge is particularly relevant for ASEAN economies such as Indonesia and Myanmar where almost one in every three individuals was between the ages of 15 and 29 years old in 2000. Annual data on the youth population comes from the United Nations' World Population Prospects data. We compute decennial intervals in order to match the time structure of the World Bank's Global Migration Database.

Because of the importance of calamities in driving migration flows in ASEAN, we also include the aggregate number of natural disasters (e.g., earthquakes, tsunamis, hurricanes, and volcanic eruptions) by origin economy in each decade as an additional determinant. Information derives from the EM-DAT Database produced by the Centre for Research on the Epidemiology of Disasters. Finally, we introduce interaction terms between a dummy variable (with a value of 1 if the economy of origin i is an ASEAN member state) and each migration determinant in order to test whether ASEAN economies behave differently than the rest of the world.

After putting together information from all of the aforementioned sources, we come up with a data set covering 157 economies for the period 1960–2000. All ASEAN member states are included in the analysis except for Myanmar.[11]

VI. Econometric Results

Results are presented in Table 2. Column 1 shows the naïve estimation where the dependent variable is the bilateral migration rate as constructed above

[10]Although unemployment rates in both origin and destination economies are a major determinant in cross-economy migration, a lack of historical data for the entire sample of economies does not allow the inclusion of unemployment among the regressors.

[11]The lack of available data for Myanmar is a problem that needs to be addressed by policy makers.

Table 2. **Gravity Model of International Migration, 1960–2000**

	(1)	(2)	(3)
Income differential	0.044	0.044	0.105
	(2.68)***	(2.68)***	(3.94)***
Income differential × ASEAN	0.162	0.161	0.276
	(5.62)***	(5.60)***	(6.45)***
Distance	−0.470	−0.470	−0.504
	(26.51)***	(26.51)***	(19.59)***
Distance × ASEAN	0.028	0.030	−0.181
	(0.45)	(0.48)	(2.02)**
Contiguity	0.454	0.454	0.166
	(3.16)***	(3.16)***	(0.87)
Contiguity × ASEAN	0.000	−0.005	0.997
	(0.00)	(0.01)	(1.57)
Social networks	0.296	0.296	0.274
	(44.55)***	(44.54)***	(29.88)***
Social networks × ASEAN	0.051	0.052	0.029
	(2.48)**	(2.54)**	(1.15)
Share of youth at origin		0.027	−0.339
		(0.23)	(1.32)
Share of youth at origin × ASEAN		0.448	0.612
		(1.38)	(0.87)
Natural disasters at origin			0.214
			(3.53)***
Natural disasters at origin × ASEAN			0.282
			(2.38)**
ASEAN	−2.221	−1.639	−0.123
	(3.75)***	(2.16)**	(0.10)
N	70,926	70,926	34,674

ASEAN = Association of Southeast Asian Nations.
Note: ***, **, and * represent 1%, 5%, and 10% significance levels, respectively.
Sources: Migration data come from Özden, Çağlar et al. 2011. "Where on Earth Is Everybody? The Evolution of Global Bilateral Migration 1960–2000." *The World Bank Economic Review* 25 (1): 12–56; gross domestic product per capita data come from Feenstra, Robert C., Robert Inklaar, and Marcel P. Timmer. 2015. "The Next Generation of the Penn World Table." *The American Economic Review* 105 (10): 3150–82; distance and common border dummies come from Head, Keith, Thierry Mayer, and John Ries. 2010. "The Erosion of Colonial Trade Linkages After Independence." *Journal of International Economics* 81 (1): 1–14; population data come from United Nations Department of Economic and Social Affairs. 2013. *World Population Prospects: The 2012 Revision*. New York: United Nations; and information on natural disasters is taken from Centre for Research on the Epidemiology of Disasters. "EM-DAT: International Disaster Database." http://www.emdat.be/database

$\left(\ln\left(\frac{N_{ij,t}}{N_{ii,t}}\right)\right)$. Income differentials appear to be significantly and positively affecting international migration, meaning that larger differentials between GDP per capita in origin and destination economies attract more migrants. This relationship is particularly important for ASEAN's origin economies, whose coefficient is almost 5 times larger than the coefficient for the rest of the world.

Physical distance between two economies plays a significant negative role in shaping migration flows, increasing migration costs and information asymmetry. On the other hand, sharing a common border is positively correlated with greater migration rates, although this effect does not seem to be particularly different for ASEAN economies than for the rest of the world. Finally, social networks in destination economies have the expected positive and significant sign since they reduce migration costs and encourage mobility. Also, as anticipated, this effect is particularly relevant for ASEAN migrants, who have been shown to rely heavily on relatives and friends abroad when engaging in the migration process (Hugo 2005).

Contrary to expectations, the population share of youth (15–29 years old) in the origin economy did not appear to have any effect on migration rates between 1960 and 2000 (Column 2). Perhaps this relationship is stronger today than it was in the past as the youth bulge was previously less of an issue given more widespread labor opportunities prior to the global financial crisis. On the other hand, natural disasters in origin economies appear to have a significant effect as a push factor of emigrants abroad. The effect is particularly important in the ASEAN economies, overall twice as large (Column 3).

In sum, this simple empirical analysis using bilateral migration data confirms that income differentials between origin and destination economies are a key driver of international migration in ASEAN economies. Similarly, migration costs appear to matter as well, with higher costs reducing the likelihood of engaging in cross-border movements. Finally, as expected, natural disasters are an important push factor globally and especially in ASEAN.

VII. Conclusions

This paper identified the main determinants of intraregional migration in ASEAN. The findings suggest that migration flows are likely to increase in the next few decades as demographic changes bring imbalances across economies that will require mobility in order to fill the consequent labor shortages. In addition, large income and wage differentials across economies will continue to play an important role in attracting migrants as long as income inequalities persist across the region. On the other side, porous borders will continue to encourage low-skilled, poor workers to migrate toward higher-income economies.

In order to achieve ASEAN's objective of creating a more thriving and inclusive community, it is necessary for governments to take measures to liberalize and regularize intraregional labor mobility. As stressed by Martin and Abella (2014), the challenge will be for ASEAN economies to open their doors to low-skilled migrants. This would reduce the magnitude of irregular cross-border movements and eliminate the cost advantages enjoyed by those firms who illegally employ such migrants over competing employers who do not.

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*ADB recognizes “Hong Kong” as Hong Kong, China.

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Household Energy Consumption and Its Determinants in Timor-Leste

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Using data from the 2007 Timor-Leste Living Standards Survey, this paper examines the determinants of household energy choices in Timor-Leste. The majority of households are dependent on dirty fuels such as fuelwood and kerosene for energy. Only a small fraction of households use clean energy such as electricity. Econometric results show that wealthy households, urban households, and those headed by individuals with higher levels of education are less likely to use and depend on kerosene and more likely to use and depend on electricity. While female-headed households are generally more likely to use and depend on fuelwood, richer female-headed households are more likely to use and depend on electricity. Our findings highlight the importance of ensuring an adequate supply of clean energy for all at affordable prices and of investing in education to raise awareness about the adverse impacts of using dirty fuels.

Keywords: education, energy, fuelwood, household, income, Timor-Leste
JEL codes: D12, I25, I31, Q42

I. Introduction

More than 1.4 billion people worldwide lack access to clean energy such as electricity, while 2.7 billion people rely on dirty energy such as biomass and fuelwood for cooking (Kaygusuz 2012).[1] Enhancing access to clean energy is a prerequisite for sustainable economic development (Spalding-Fecher 2005, Abebaw 2007). Alarmingly, a lack of access to clean energy is found to be associated with ill health and the prevalence of poverty (Ekholm et al. 2010). Unfortunately, the majority of households, particularly in rural areas in developing economies, lack access to clean energy sources such as electricity even though demand for clean energy consistently increases in line with rising household incomes in these economies.

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[1] As electricity and gas pollute the atmosphere less than coal, kerosene, and fuelwood, the former are referred to as "clean energy," while the later are referred to as "dirty energy."

Inadequate supply, the consequent high costs, and a lack of purchasing power are the major barriers to a household's conversion to clean energy sources in developing economies (Arntzen and Kgathi 1984; Heltberg, Arndt, and Sekhar 2000). The price of energy increases with improvements in energy quality and its ease of use (Behera et al. 2015, Rahut et al. 2014).[2] For example, fuel costs increase as a household shifts from solid fuels such as biomass to other fuels such as gas and electricity. The energy ladder hypothesis postulates that with increases in income and awareness, households gradually shift from solid fuels to more modern and efficient energy sources such as liquid petroleum gas, natural gas, and electricity (Leach 1975, 1992). Several studies have documented that the energy sources used by households change as income levels increase (Rao and Reddy 2007; Khandker, Barnes, and Samad 2012; Rahut, Behera, and Ali 2016), with a shift from traditional to modern fuels (Daioglou, Van Ruijven, and Van Vuuren 2012), particularly electricity (Hills 1994). A few studies, however, have found that increased incomes do not always lead to households switching to cleaner fuels (Masera, Saatkamp, and Kammen 2000; Nansaior et al. 2011; Huang 2015). Thus, the direction of the relationship between income and the demand for clean energy remains uncertain and thus requires further investigation using large samples across economies (Khandker, Barnes, and Samad 2012).

Using data from the 2007 Timor-Leste Survey of Living Standards (TLSLS), this paper analyzes the influences of income and human capital on household energy choices in developing economies. Understanding patterns of household energy consumption and the determinants of energy choices is important. Timor-Leste, a newly independent small country in Southeast Asia with an area of 15,410 square kilometers and a population of 1.2 million, is one of the poorest economies in the world with a poverty rate of 27% (Datt et al. 2008). It was a Portuguese colony for 450 years and later governed by Indonesia from 1976 to 2002. On 20 May 2002, Timor-Leste became a sovereign state, joining the United Nations and the Community of Portuguese Language Countries.

Since independence, Timor-Leste has aspired to boost the provision of electricity through a grid extension program based on the national rural electrification master plan (Government of Timor-Leste 2012). In 2002, only 36% of Timor-Leste's 0.825 million people had access to electricity, most of whom were concentrated in the capital of Dili (International Monetary Fund 2004). In its most recent survey, the World Bank found that access to electricity was limited to 6%–10% of rural households (World Bank 2005). The nearly two-thirds of all households in Timor-Leste that lack access to electricity mainly depend on kerosene and candles to meet their lighting needs. Fuelwood is the cheapest form of fuel available and

[2]In this paper, the quality of an energy source is defined in terms of the nature of its pollution. Sources of energy that emit smoke and pollute the environment like fuelwood, dung cake, coal, and kerosene are regarded as low quality sources of energy. Sources like liquid petroleum gas and electricity are regarded as high quality.

is used by 95% of households in Timor-Leste for cooking (World Bank 2005). This heavy reliance on fuelwood is the main cause of rapid deforestation in Timor-Leste. In addition, the indoor air pollution generated using fuelwood is a major concern for human health. In 2003, total health expenditure from indoor air pollution was estimated at $12.4 million, or 1.4% of gross national income (Arcenas et al. 2010).

Households in Timor-Leste spend an average of $14.3 on energy per month, which is the equivalent of 20% of a typical rural household's monthly income and on average, members of a household spend 3.5 hours per day for cooking and allocate 6 hours per week for collecting fuelwood (Mercy Corps 2011). An average household uses 9.3 kilograms of fuelwood daily and 3 tons annually (Mercy Corps 2011). In addition to being the primary source of deforestation, this massive use of fuelwood negatively affects the agricultural systems of Timor-Leste (World Bank 2010).

Timor-Leste has vast reserves of natural gas in the Timor Sea and thus has great potential for generating electricity cheaply (Strategic Development Plan 2011). Against this backdrop, an analysis of household energy choices in a newly independent and poverty-stricken developing economy can provide guidance to policy makers and international donors on what types of energy should be promoted for facilitating rapid economic development and reducing widespread poverty.

This paper makes four distinct contributions to the existing literature. To the best of our knowledge, no such energy study has been carried out in Timor-Leste using large, nationally representative household data sets. Thus, this study can provide insight to policy makers and donor agencies on domestic energy policy in Timor-Leste. Second, the study confirms the existing energy ladder hypothesis, which suggests there is (i) an inverse relationship between household wealth and education levels and the use of traditional energy such as biomass, and (ii) a positive relationship between household wealth and education levels and the use of clean energy such as electricity. Third, this paper is unique in using econometric models, including a multivariate probit model to analyze the factors influencing household energy choices and a Tobit model to examine the intensity of energy consumption based on the share of household expenditure allocated for different energy sources. Finally, we reestimate our econometric models by splitting and employing the sampled observations into 75%, 50%, and 25% segments to examine the robustness and sensitivity of the findings.

The paper is organized as follows. Section II includes a brief literature review and two testable hypotheses. Section III outlines the data sources and data collection process, as well as the specification of econometric models. We subsequently present descriptive analyses, empirical results, and discussions of the determinants of household energy choices in section IV. Section V presents consumption intensity. Section VI presents major empirical findings. Section VII concludes with a discussion of the policy implications.

II. Literature Review and Testable Hypotheses

The energy ladder hypothesis postulates that as incomes rise households gradually shift from solid fuels to more modern and efficient energy sources such as kerosene, liquid petroleum gas, natural gas, and electricity (Leach 1975, 1992). Thus, the transition from solid fuels to more efficient and modern energy sources is greatly influenced by household income (Hills 1994; Rao and Reddy 2007; Daioglou, Van Ruijven, and Van Vuuren 2012; Khandker, Barnes, and Samad 2012). With an increase in income, the opportunity cost of collecting fuelwood increases. In many cases, it might be more efficient for high-income households to switch to natural gas, kerosene, or electricity as a source of fuel rather than collecting fuelwood given the rising opportunity cost involved. A few studies, however, failed to establish any correlation between rising incomes and households switching to efficient energy (Masera, Saatkamp, and Kammen 2000; Nansaior et al. 2011). To understand the direction of the relationship between income and energy choices as incomes rise, we postulate the following hypothesis:

Hypothesis (1): It is highly likely that households with relatively higher incomes are less likely to depend on kerosene and fuelwood and more likely to choose electricity and other efficient fuels. Thus, they will spend relatively more income on clean energy such as electricity.

Household demographics such as the sex of a household head can have a significant influence on energy choices as female members have a strong preference for using cleaner and more convenient energy sources. In developing economies, female household members are generally responsible for collecting fuelwood and cooking (Farhar 1998). For example, in India, females are more involved in collecting fuelwood from forests than their male counterparts (Heltberg, Arndt, and Sekhar 2000). Thus, female household members play an active role in energy use from collecting fuel to making decisions on fuel sources (Reddy and Srinivas 2009). Use of clean energy has a positive impact on the health and well-being of households, particularly children and female members. Hence, when a female member is the principal decision-making agent (household head), higher priority will be given to the use of clean energy (Parikh 1995; Rahut, Behera, and Ali 2016), which is why empirical evidence strongly suggests that per capita fuelwood consumption in female-headed households is less than in male-headed households (Israel 2002). The age of the household head and family size can also play important roles in energy choices. While households with more family members need more energy, such households are also able to supply more labor for fuelwood collection and other activities in rural areas (Dewees 1989; Heltberg, Arndt, and Sekhar 2000; Nepal, Nepal, and Grimsrud 2011). Empirical evidence indicates an inverse relationship between family size and the use of clean fuel (Pandey and Chaubal 2011).

In addition to income and household demographics, the level of education of the household head, which can serve as a proxy for the level of human capital at the household level, can also affect household energy choices through enhanced nonfarm income and thus the affordability of more efficient energy sources, the increased opportunity cost of the time required for fuelwood collection, and raised awareness of the harmful effects of dirty fuel on the environment and health (Leach 1975, 1992). It is well documented that the use of solid fuels is detrimental to the environment and health (Bruce, Perez-Padilla, and Albalak 2000; Holdren et al. 2000; Rehfuess, Mehta, and Prüss-Üstün 2006). Empirical evidence confirms that education is a strong determinant of switching from traditional solid fuels to more efficient modern fuels (Heltberg 2005, Pachauri and Jiang 2008). To examine the relationship between choice of energy sources and household demographics and human capital, the following hypothesis is formulated:

Hypothesis (2): While households with more family members are more likely to depend on fuelwood and electricity for energy and therefore spend a relatively larger share of total energy expenditure on these sources, relatively more educated household heads are less likely to choose kerosene and therefore spend relatively less on it and more likely to choose clean energy such as electricity and therefore spend relatively more on it.

Generally, the focus of energy policy is to create incentives and enable households in developing economies to switch from traditional fuels such as biomass and fuelwood to clean energy such as electricity. By examining our testable hypotheses, this paper investigates household patterns of energy consumption and analyzes the factors that influence household energy choices in developing economies by using data collected under the TLSLS 2007 from more than 4,000 rural and urban households in Timor-Leste.

III. Data and Methodology

A. Data and Sampling

This paper uses data from the TLSLS 2007 to analyze household-level energy consumption and its determinants. The TLSLS is a government-administered activity with financial, intellectual, and technical support from the multidonor Planning and Financial Management Capacity Building Program managed by the World Bank.[3] The TLSLS is a comprehensive multimodule survey encompassing broad topics. Samples were selected in two stages. In the first stage, 300 census

[3]Meta data and detailed documentation can be found at http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/0,,contentMDK:22764522~pagePK:64168445~piPK:64168309~theSitePK:3358997,00.html

Table 1. **TLSLS Distribution of Enumeration Areas and Full Sample by Region and Household Rural–Urban Status**

	Number of Enumeration Areas			Sampled Households		
Regions	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
1 (Baucau, Lautem, and Viqueque)	35	25	60	524	375	899
2 (Ainaro, Manufahi, and Manatuto)	35	25	60	517	374	891
3 (Aileu, Dili, and Ermera)	35	37	72	522	552	1,074
4 (Bobonaro, Cova Lima, and Liquica)	35	25	60	520	375	895
5 (Oecussi)	28	20	48	419	229	648
Total	**168**	**132**	**300**	**2,502**	**1,905**	**4,407**

TLSLS = Timor-Leste Survey of Living Standards.
Source: Government of Timor-Leste, Ministry of Finance. "Timor-Leste Survey of Living Standards 2007." http://www.statistics.gov.tl/wp-content/uploads/2013/12/Timor-Leste-Survey-of-Living-Standards-2007.pdf

Enumeration Areas were selected as the primary sampling units; in the second stage, 15 households were selected from each Enumeration Area. The first sampling stage used the list of 1,163 Enumeration Areas generated by the 2004 census as a sampling frame. Within each stratum, the allocated number of Enumeration Areas was selected with probability proportional to size, using the number of households reported by the census as a measure of size. The second sampling stage used an exhaustive household listing operation in all selected Enumeration Areas as its sampling frame. Sampled households in each Enumeration Area were selected from the list by systematic equal probability sampling. Table 1 shows the TLSLS distribution of the Enumeration Areas and full sample by region and by household rural–urban status.

B. Methodology

Generally, households depend on energy from multiple sources. Therefore, the choices to use a variety of individual energy sources are correlated with each other. To capture the mutually inclusive behavior of household energy choices, a multivariate probit model was employed to analyze the determinants of a household's energy choices. To test hypothesis 1 and hypothesis 2, we randomly split the total sample into four equal groups. While we first ran the multivariate probit model using the total sample, we subsequently ran the same model using 75%, 50%, and 25% segments of the total sample. We then compared the coefficients of different household income levels and different levels of education of the household head against energy use choices and the expenditure shares on different energy sources. In the multivariate probit model, sources of energy such as fuelwood, kerosene, electricity, and others are considered dependent variables. The independent variables include household demographic characteristics, labor supply, human and physical capital, and location dummies. One advantage of the multivariate probit model is that, unlike single-equation probit and logit models, the multivariate probit model simultaneously analyzes the choice of energy by the source of energy.

We follow Lin, Jensen, and Yen (2005) in formulating the multivariate model, which has four dependent variables, $y_1 \ldots y_4$:

$$y_i = 1 \ \ if \ \ \beta_i X' + \varepsilon_i > 0 \tag{1}$$

and

$$y_i = 0 \ \ if \ \ \beta_i X' + \varepsilon_i \leq 0, i = 1, 2, \ldots, 5 \tag{2}$$

where x is a vector of the explanatory variables; β_1, β_2, β_3, β_4, and β_5 are conformable parameter vectors; and ε_1, ε_2, ε_3, ε_4, and ε_5 are random errors distributed as a multivariate normal distribution with zero mean, unitary variance, and an $n \ X \ n$.

As information on household expenditure on fuel by source is available, we generated a variable by dividing the fuel expenditure for each source by total energy expenditure per household.[4] The proportion of expenditure on each energy source reveals the dependency on different sources of energy at the household level. Since the dependent variable is a fraction ranging from 0 to 1, we employed a Tobit model (censored at 0) to analyze the determinants of household energy dependency.

To examine hypotheses 1 and 2 with respect to the influence of a household's income and the level of education of the household head on expenditure on different energy sources, we ran a Tobit model first using the entire sample and then using segments equal to 75%, 50%, and 25% of the total observations. Due to a previous lack of information on expenditure on energy sources, most past studies have focused simply on choices (Rahut et al. 2014), which is an approach that fails to capture the level of dependency on energy sources as measured by expenditure size. Our study fills in this research gap by using data on expenditure to determine household dependency on particular fuel sources.

The intensity of consumption of different sources of energy is estimated using a censored Tobit model. The ratio of a household's expenditure on different sources of energy to total expenditure on energy is used to measure the intensity of consumption.

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[4]For example, household expenditure on kerosene is divided by total household expenditure on fuel.

The intensity of fuel consumption is censored from the lower tail by specifying the level of intensity below which a household is not regarded as having consumed a particular source of energy. Thus, the Tobit model assumes a latent variable x_i^* that is generated by the following function:

$$x_i^* = \beta_x' z_i + \varepsilon_{xi} \tag{3}$$

where x_i^* is the latent variable that truncates the consumption of particular sources of energy, z_i is a vector of household and location characteristics, β_{xi} is a vector of coefficients to be estimated, and ε_{xi} is a scalar of error terms assumed to be independently and normally distributed with mean 0 and constant variance σ^2. Given this function, the specification of household intensity of consumption of a particular source of energy is expressed as

$$x_i = x_i^* \text{ if } x_i^* \geq d \tag{4}$$

and

$$x_i = 0 \text{ if } x_i^* < d \tag{5}$$

Where d is an established threshold that distinguishes households that use a particular source of energy from those that do not. The probability function for nonusers is

$$p(x_i^* < d) = \Phi\left(\frac{\beta_x' z_i}{\sigma}\right) \tag{6}$$

and the density for households that use a particular source of energy is

$$f(x_i | x_i^* \geq d) = \frac{f(x_i)}{p(x_i^* \geq d)} = \frac{\frac{1}{\sigma}\phi\left(\frac{x_i^* - \beta_{x_i^*}' z_i}{\sigma}\right)}{\Phi\left(\frac{\beta_{x_i^*}' z_i}{\sigma}\right)} \tag{7}$$

where $\Phi(.)$ and $\phi(.)$ are the standard normal cumulative and probability density functions, respectively. The density function represents the truncated regression model for those households whose observed consumption of a particular source of energy is greater than the threshold.

The log-likelihood function for the Tobit model is given as a summation of the probability functions for both users and nonusers of a particular source of

Table 2. **Household Energy Sources and Expenditure as a Share of the Total**

Household Energy Sources	**Frequency of Use (%)**
Kerosene	74.9
Fuelwood	85.3
Electricity	23.2
Other fuels	5.1
Expenditure per Energy Source	**Share of Total (%)**
Kerosene	31.8
Fuelwood	56.8
Electricity	9.9
Other fuels	1.5

Note: Energy choices are not mutually exclusive; that is, households can simultaneously use a mix of energy sources.
Source: Authors' calculations based on Government of Timor-Leste, Ministry of Finance. "Timor-Leste Survey of Living Standards 2007." http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/0,,contentMDK:22764522~pagePK:64168445~piPK:64168309~theSitePK:3358997,00.html

energy:

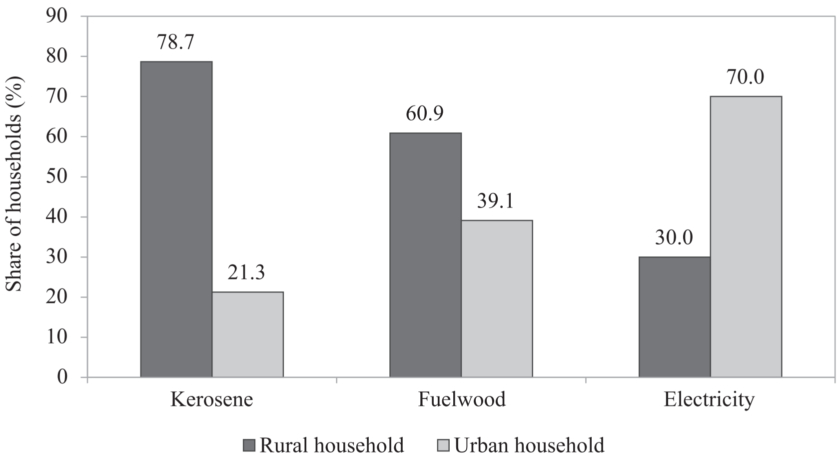
$$\ln L = \sum_{x_i^* < d} \ln \left(1 - \Phi \left(\frac{\beta'_{x_i^*} z_i}{\sigma} \right) \right) + \sum_{x_i^* \geq d} \ln \frac{1}{\sigma} \phi \left(\frac{x_i^* - \beta'_{x_i^*} z_i}{\sigma} \right) \tag{8}$$

IV. General Findings

A. Descriptive Statistics

Table 2 shows the distribution of household energy sources by use and expenditure. The majority of households in Timor-Leste use fuelwood (85.3%) and kerosene (74.9%) for domestic purposes, while only 23.2% of households use electricity. Fuelwood comprises 56.8% of total household expenditure on fuel consumption, kerosene accounts for 31.8%, and electricity comprises only 9.9%. High levels of consumption of dirty fuels like wood and kerosene have adverse effects on human health. Solid fuels like wood, dung, and coal are the most significant sources of indoor air pollution, and exposure to the byproducts of the combustion of biomass fuels, particularly wood smoke, has been linked to numerous health problems (Sanyal and Maduna 2000; Torres-Duque et al. 2008; Ingale et al. 2013; Oguntoke, Adebulehin, and Annegarn 2013; Oluwole et al. 2013). Bruce, Perez-Padilla, and Albalak (2000) reported that exposure to indoor air pollution may have been responsible at the time for nearly 2 million avoidable deaths in developing economies and about 4% of the total global disease burden.

Figure 1. **Distribution of Households Energy Sources—Rural versus Urban**



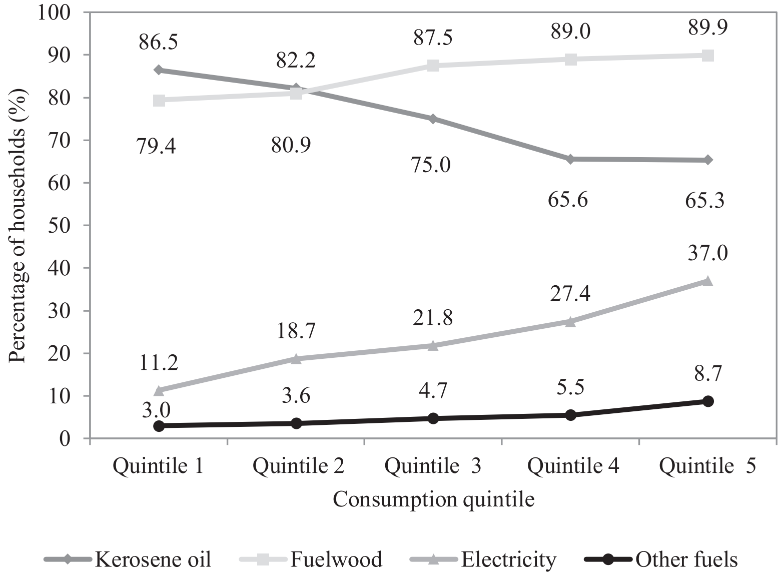
Source: Authors' calculations based on Government of Timor-Leste, Ministry of Finance. "Timor-Leste Survey of Living Standards 2007." http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/0,,contentMDK:22764522~pagePK:64168445~piPK:64168309~theSitePK:3358997,00.html

Figure 1 shows the distribution of household energy sources by location (rural versus urban). We find that 78.7% of the households in Timor-Leste using kerosene oil and 60.9% of those using fuelwood are located in rural areas. Among all households using electricity, only 30% are located in rural areas. The majority of rural households use dirty fuel and only a small proportion of all rural households use clean energy like electricity.

Globally, about 50% of all households and about 90% of rural households use solid fuels such as coal and biomass as their main domestic source of energy, which means that approximately 50% of the world's population—more than 3 billion people—are exposed to the harmful effects of the combustion of these fuels (Torres-Duque et al. 2008).

Figure 2 presents household energy sources by consumption quintile, which shows that the percentage of households using electricity increases across consumption quintiles while the percentage of households using kerosene decreases. Only 11.2% of households in the first consumption quintile (poorest 20%) use electricity, while 27.4% of households in the fourth quintile and 37% of those in the fifth quintile (richest 20%) use electricity. About 86.5% of households in the first quintile use kerosene, while 65.3% of those in the fifth quintile use kerosene. The percentage of households using fuelwood also increases with rising income, indicating that the economic status of the household influences the consumption of fuelwood, which is contrary to the general finding that with an increase in income the percentage of households using fuelwood decreases (Barnes and Floor 1999; Heltberg 2005; Rao and Reddy 2007; Pachauri and Jiang 2008; Kwakwa, Wiafe, and Alhassan 2013; Rahut et al. 2014; Behera et al. 2015). In Timor-Leste, as in many

Figure 2. **Distribution of Household Energy Sources by Consumption Quintile**



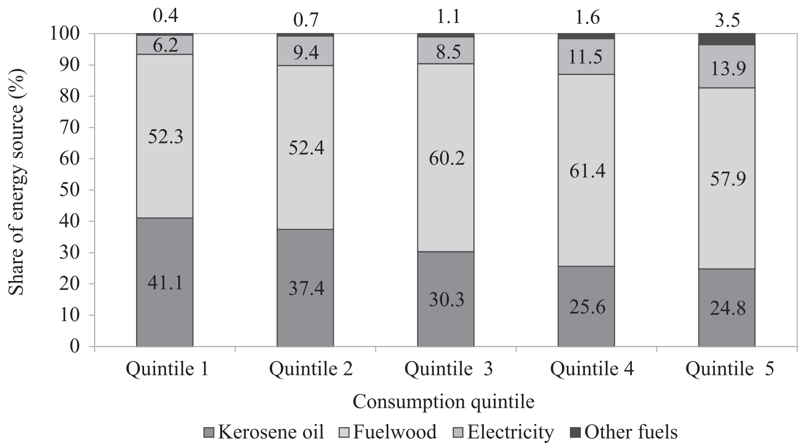
Source: Authors' calculations based on Government of Timor-Leste, Ministry of Finance. "Timor-Leste Survey of Living Standards 2007." http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/0,,contentMDK:22764522~pagePK:64168445~piPK:64168309~theSitePK:3358997,00.html

developing economies, fuelwood is relatively cheap and available, leading to higher levels of consumption. Furthermore, fuelwood's use for domestic energy purposes is widely accepted in Timor-Leste. The abundance of and access to fuelwood, as well as cultural norms, might even encourage higher levels of fuelwood use among relatively wealthy households in Timor-Leste.

Figure 3 presents the shares of household energy expenditure across consumption quintiles. Using household expenditure as the unit of measurement, electricity consumption as a share of total household energy consumption increases as household income increases, while the share of kerosene consumption decreases with an increase in income. For the poorest 20% of households, electricity comprises 6.2% of total household energy consumption, while for the richest 20% it accounts for 13.9%. Kerosene comprises 41.1% of energy consumption among the poorest quintile of households and only 24.8% of energy consumption among the richest quintile. Figure 3 demonstrates that households in Timor-Leste with higher incomes tend to depend more on clean energy such as electricity than dirty fuels such as kerosene, confirming the findings of other studies on household energy consumption in developing economies (Heltberg 2004, Pachauri 2004, Rao and Reddy 2007, Reddy and Srinivas 2009, Rahut et al. 2014).

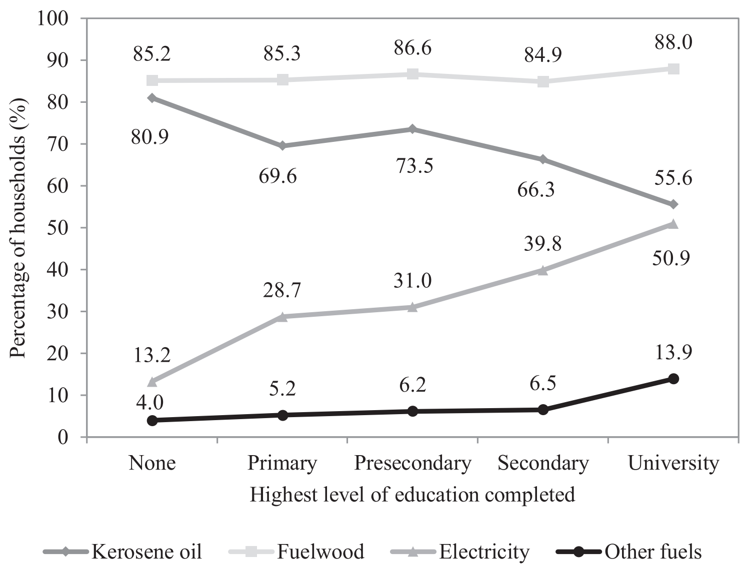
Figure 4 presents household energy use patterns based on the level of education of the head of the household. The percentage of households using kerosene

Figure 3. **Distribution of Household Energy Expenditure by Consumption Quintile**



Source: Authors' calculations based on Government of Timor-Leste, Ministry of Finance. "Timor-Leste Survey of Living Standards 2007." http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/0,,contentMDK:22764522~pagePK:64168445~piPK:64168309~theSitePK:3358997,00.html

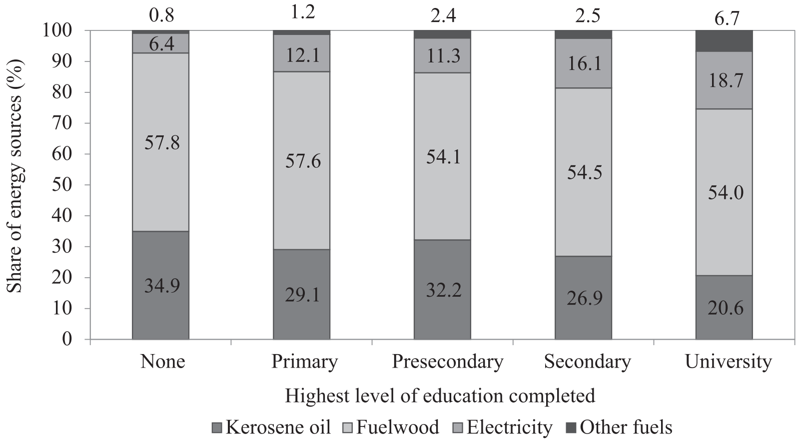
Figure 4. **Distribution of Household Energy Sources by Level of Education of the Household Head**



Source: Authors' calculations based on Timor-Leste Living Standards Survey Data 2007.

falls with an increase in the level of education of the household head, while the percentage of households using electricity rises with an increase in the household head's education level. Only 13.2% of households headed by individuals without an education use electricity, while 50.9% of households headed by an individual

Figure 5. **Distribution of Household Energy Expenditure by Level of Education of the Household Head**



Source: Authors' calculations based on Government of Timor-Leste, Ministry of Finance. "Timor-Leste Survey of Living Standards 2007." http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/0,,contentMDK:22764522~pagePK:64168445~piPK:64168309~theSitePK:3358997,00.html

with a university degree use electricity. About 80.9% of households headed by an individual without an education use kerosene, while 55.6% of households with a university-educated head use kerosene. Interestingly, the percentage of households using fuelwood is fairly constant across levels of education.

Figure 5 presents household expenditure shares for different sources of energy by the level of education of the household head. The share of expenditure utilized for electricity increases with an increase in the level of education of the household head, while the share of expenditure for kerosene decreases. Electricity accounts for only 6.4% of total energy consumption expenditure for households headed by an individual with no formal education, compared with 18.7% for households headed by those with a university degree. In households headed by someone without any formal education, kerosene contributes 34.9% of energy consumption expenditure, compared with 20.6% for households with a university-educated head. Figures 4 and 5 demonstrate that as incomes and education levels rise, households tend to use more and spend more on clean energy such as electricity.

B. Empirical Model

1. Household Energy Choices—Estimation of Multivariate Probit Model

Table 3 presents the pairwise correlation coefficients showing the relationship between various energy source choices made by households. Overall, the result shows a positive correlation among dirty energy sources and a negative relationship

Table 3. **Correlation Coefficients of Household Energy Sources**

Household energy sources for domestic use	**Correlation Coefficient**	**Standard Error**
Kerosene and fuelwood	0.06	0.04
Kerosene and electricity	−0.60***	0.04
Kerosene and other fuels	0.07	0.08
Fuelwood and electricity	−0.34***	0.04
Fuelwood and other fuels	−0.20**	0.08
Electricity and other fuels	0.15**	0.07

Notes: Correlation coefficients are derived from the multivariate probit estimations in Table 4. * = 10% level of significance, ** = 5% level of significance, *** = 1% level of significance. LR test for rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0: $chi^2(6) = 455669$ Prob. > chi2 = 0.0000.
Source: Authors' calculations.

between clean and dirty sources of energy. A positive and significant correlation is observed between the use of kerosene and fuelwood, both of which are considered dirty sources of energy. A positive correlation is noted between kerosene and other fuels. Interestingly, Table 3 shows negative and significant correlations between kerosene and electricity, and fuelwood and electricity, indicating that a household which depends on electricity as a source of energy also tends to use fuels other than kerosene or fuelwood. This is likely because of the relatively high purchasing power of households that use electricity. Table 3 generally confirms that households usually depend on more than a single source of energy. For example, a household may depend on electricity for lighting and fuelwood for cooking. Thus, energy sources are not mutually exclusive within a single household, which allows us to employ a multivariate probit model in estimating household choices of different energy sources.

Table 4 presents the estimated functions of household energy sources in relation to household characteristics. Results from the multivariate probit on energy choices show that with an increase in the age of the household head, the likelihood of using electricity increases up until 54 years of age. The coefficient of the female-headed household variable (yes = 1) is negative and significant for kerosene and other fuels, and is positive and highly significant for fuelwood ($P < 0.00$). This finding confirms that in developing economies, female members are more involved in collecting fuelwood from forests than their male counterparts (Heltberg, Arndt, and Sekhar 2000). Consequently, a female-headed household is more likely to choose fuelwood as a source of energy (Reddy and Srinivas 2009). The multiplicative dummies in Table 4, which are generated by multiplying the female-headed household dummy with consumption quintiles, show that relatively rich female-headed households are less likely to use fuelwood as a source of energy since there is a higher opportunity cost of collecting fuelwood for these households.

Table 4. **Functions Estimated Using a Multivariate Probit Model to Explain Household Energy Choices**

Estimation Method	**Multivariate Probit**			
Dependent variables: Energy source	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**
Demographics				
Age, household head	0.001	−0.018	0.043***	0.048*
	(0.01)	(0.01)	(0.01)	(0.03)
Age squared, household head	−0.00003	0.0001	−0.0004***	−0.001**
	(0.00)	(0.00)	(0.00)	(0.00)
Female-headed household[a,b]	0.01	0.71***	−0.02	0.51
	(0.23)	(0.22)	(0.26)	(0.43)
Household size (no. of family members)	−0.05***	0.11***	0.08***	0.08***
	(0.01)	(0.02)	(0.01)	(0.02)
Human capital				
Primary completed[a,c]	−0.15*	−0.17**	0.43***	−0.050
	(0.08)	(0.08)	(0.08)	(0.13)
Presecondary completed[a,c]	−0.07	−0.0033	0.61***	0.16
	(0.11)	(0.12)	(0.11)	(0.17)
Secondary completed[a,c]	−0.17*	−0.34***	0.58***	−0.12
	(0.10)	(0.10)	(0.10)	(0.15)
University completed[a,c]	−0.47**	−0.63***	0.50***	0.57**
	(0.18)	(0.23)	(0.18)	(0.27)
Consumption quintile				
Consumption quintile 2[a,d]	0.03	0.18*	0.30***	0.53***
	(0.11)	(0.10)	(0.11)	(0.18)
Consumption quintile 3[a,d]	−0.17	0.59***	0.38***	0.70***
	(0.11)	(0.11)	(0.11)	(0.18)
Consumption quintile 4[a,d]	−0.40***	0.71***	0.57***	1.02***
	(0.11)	(0.11)	(0.12)	(0.18)
Consumption quintile 5[a,d]	−0.38***	0.79***	0.84***	1.13***
	(0.12)	(0.14)	(0.13)	(0.19)
Location				
Rural household[e]	0.86***	−0.33***	−0.55***	0.07
	(0.06)	(0.07)	(0.07)	(0.10)
Gender and consumption quintile				
Female-headed household × consumption quintile 2	−0.13	−0.55*	0.14	−1.04*
	(0.30)	(0.29)	(0.32)	(0.54)
Female-headed household × consumption quintile 3	−0.38	−0.82***	0.07	−0.58
	(0.29)	(0.30)	(0.32)	(0.60)
Female-headed household × consumption quintile 4	−0.06	−0.61**	−0.07	−0.76
	(0.28)	(0.30)	(0.32)	(0.54)
Female-headed household × consumption quintile 5	−0.18	−0.54*	−0.14	−0.86
	(0.28)	(0.29)	(0.30)	(0.56)
Regions				
Region 2 (Manatuto, Manufahi, Ainaro)[d,f]	1.23***	−0.64***	−0.40***	0.005
	(0.10)	(0.09)	(0.08)	(0.20)
Region 3 (Dili, Aileu, Ermera)[d,f]	0.77***	−0.18**	−1.02***	−0.44***
	(0.08)	(0.09)	(0.09)	(0.16)
Region 4 (Bobonaro, Cova Lima, Liquiçá)[d,f]	1.11***	0.21**	−0.70***	0.20
	(0.09)	(0.09)	(0.09)	(0.16)
Region 5 (Oecusse)[d,f]	1.62***	1.00***	−0.91***	1.39***
	(0.15)	(0.17)	(0.08)	(0.16)

Continued.

Table 4. *Continued.*

Estimation Method	**Multivariate Probit**			
Dependent variables: Energy source	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**
Constant	−0.08	1.10***	−2.25***	−4.11***
	(0.35)	(0.37)	(0.38)	(0.66)
No. of observations	4,357			
Wald Chi^2 (84)	1,586.27			
Prob. > chi2	0.000			
Log pseudolikelihood	−233,621.94			

[a]Dummy variables
[b]Excluded category: male-headed households
[c]Excluded category: household head with no education
[d]Excluded category: consumption quintile 1
[e]Excluded category: urban households
[f]Excluded region: Region I: (Baucau, Lautém, Viqueque)
Notes: Standard errors in parentheses. * = 10% level of significance, ** = 5% level of significance, *** = 1% level of significance.
Source: Authors' calculations.

The findings confirm that, while in general households headed by a female are more likely to use fuelwood as their primary source of energy, relatively wealthy female-headed households are less likely to use fuelwood as their primary source of energy.

The coefficient of household size is positive and significant with respect to the use of fuelwood, electricity, and other fuels, while it is negative and significant for kerosene. The findings in Table 4 strongly support the first part of hypothesis (2), which is that household size positively and significantly influences the choice of and expenditure on fuelwood, electricity, and energy sources other than kerosene. The positive relationship between household size and fuelwood can be explained by the increased availability of family labor to collect fuelwood and the greater demand for energy in larger households. This finding supports results from past studies on household energy use in developing economies that illustrate the positive correlation between fuelwood and household size (Heltberg 2004).

In order to examine the influence of education on energy choices, which is covered in the second part of hypothesis (1), we included four dummies for the level of education of the household head: primary completed (1), presecondary completed (2), secondary completed (3), and university completed (4). Thus, the excluded category is no education (0). The results in Table 4 show that compared with households headed by individuals with no education, the probability of choosing kerosene and wood as sources of fuel decreases as the level of education rises. For kerosene, the coefficients of the variables are as follows: primary completed (−0.15 [$P < 0.10$]), secondary completed (−0.17 [$P < 0.10$]), and university completed (−0.47 [$P < 0.05\%$]). For fuelwood, the coefficients of the variables are as follows: (−0.17 [$P < 0.05$]), secondary completed (−0.34 [$P < 0.10$]), and university completed (−0.63 [$P < 0.05$]). The coefficients of the dummies for presecondary completed for kerosene and fuelwood are both negative but insignificant. Table 4 clearly shows that the probability of the choice of electricity for domestic energy use increases with an increase in the level of education of the household head. In the energy choice model, the coefficient of the primary completed variable for the household head is 0.43, for presecondary completed it is 0.61, for secondary completed it is 0.58, and for a university degree it is 0.5. All of these coefficients are significant at the 1% level.

To examine hypothesis (1), which covers the effects of income on the choice of domestic energy use, we used the consumption quintiles as independent variables in the estimated functions shown in Table 4. The results indicate that the likelihood of the choice of kerosene decreases, while the choice of fuelwood, electricity, and other fuels increases progressively in relation to consumption quintiles. For example, the coefficients for the choice of kerosene are −0.40 ($P < 0.00$) for consumption quintile 4 and −0.38 ($P < 0.00$) for consumption quintile 5. (Consumption quintile 1 is the base in this case.) The coefficients for the choice of fuelwood are 0.18 (significant at the 10% level) for consumption quintile 2, 0.59 (significant at the 1% level) for consumption quintile 3, 0.71 (significant at the 1% level) for consumption quintile 4, and 0.79 (significant at the 1% level) for consumption quintile 5. The coefficients for the choice of electricity are 0.3 for consumption quintile 2, 0.38 for consumption quintile 3, 0.57 for consumption quintile 4, and 0.84 for consumption quintile 5. All are significant at the 1% level. Coefficients for the choice of other energy sources are 0.53 for consumption quintile 2, 0.7 for consumption quintile 3, 1.02 for consumption quintile 4, and 1.13 for consumption quintile 4. All are significant at the 1% level. The findings indicate that relatively affluent households are more likely to choose fuelwood as well as clean energy such as electricity as the main sources of energy for their homes.

The coefficients of the rural household dummy (yes = 1) are 0.86 (significant at the 1% level) for the choice of kerosene, −0.33 (significant at the 1% level) for fuelwood, and −0.55 (significant at the 1% level) for electricity, indicating that, when compared with urban households, rural households are more likely to choose kerosene and less likely to choose fuelwood and electricity.

To capture the effects of regional heterogeneity in fuel choices among sampled households, four regional dummies for five regions were included in estimating the functions in Table 4. The base region is Region 1, comprising Baucau, Lautem, and Viqueque districts. The regional dummies in Table 4 show that compared with households located in Region 1, households in all other regions are more likely to use kerosene and less likely to use electricity as a source of fuel. The households in Region 4, comprising Bobonaro, Coval Mia, and Liquica districts, and Region 5, comprising Oecusse district, are more likely to choose fuelwood than households located in the base region.

2. Intensity of Consumption of Energy by Sources—Results and Discussion from the Tobit Model

The multivariate probit model in Table 4 only assesses the choice of a particular energy source at the household level. It does not tell the extent to which households are dependent on different sources of energy. In order to assess a household's dependency on a particular source of energy, we employed a tobit model in which the dependent variable is expenditure on a particular source of energy divided by the total energy expenditure of a household (Table 5).

Estimated functions in Table 5 present the intensity of a particular energy source used by households. Similar to the energy choice model (Table 4), the results show that with an increase in the age of the household head the consumption of both electricity and other fuels increases in relation to total energy consumption. However, dependency on electricity and other fuels, in terms of the share of household expenditure, declines with the age of the household head. Female-headed households are less likely to depend on kerosene and more likely to depend on fuelwood than their male-headed counterparts. However, there is no statistically significant relationship between wealthy female-headed households and dependency on a particular fuel. This means that the share of expenditure on all fuels almost remains the same among female-headed households irrespective of income. With an increase in family size, households are more likely to be dependent on fuelwood, electricity, and other fuels, while dependence on kerosene decreases as households expand in size.

Importantly, there is no significant relationship between the level of education of the household head and dependency on kerosene. This means that the use of kerosene remains nearly the same among all households irrespective of the level of education of the household head. The degree of dependency on fuelwood decreases with an increase in the level of education of the household head. In contrast, the degree of dependency on electricity increases with an increase in the level of education of the household head. The function explaining expenditure share on fuelwood shows that the coefficient of the dummy for a household head who has completed a primary education is −0.05 (significant at the 1% level), a presecondary education is 0.06 (significant at the 1% level), a secondary education is −0.10 (significant at the 1% level), and a university education is −0.15 (significant at the 5% level). In contrast, the coefficient of the dummy variable for a household head with a primary education is 0.29, a presecondary education is 0.37, a secondary education is 0.42, and a university education is 0.37. All of these coefficients are significant at the 1% level. In the case of other fuels, the dummy variable for a household head with a university degree is positive and significant at the 5% level.

Table 5 shows that with an increase in wealth, dependency on kerosene decreases and dependency on fuelwood, electricity, and other fuels increases. The coefficient of the rural dummy is 0.24 (significant at the 1% level) for the share of

Table 5. **Functions Estimated Using a Two-Limit Tobit Model to Explain Household Expenditure on Different Energy Sources**

Dependent variables	**Share of expenditure on kerosene**	**Share of expenditure on fuelwood**	**Share of expenditure on electricity**	**Share of expenditure on other fuels**
Demographics				
Age, household head	0.0017	−0.0061*	0.026**	0.040*
	(0.00)	(0.00)	(0.01)	(0.02)
Age squared, household head	−0.0000096	0.000044	−0.00021*	−0.00052**
	(0.00)	(0.00)	(0.00)	(0.00)
Female-headed household[a,b]	−0.12***	0.10***	0.0090	0.41
	(0.04)	(0.04)	(0.19)	(0.34)
Household size (no. of family members)	−0.032***	0.020***	0.047***	0.068***
	(0.00)	(0.00)	(0.01)	(0.02)
Human capital				
Primary completed[a,c]	−0.0019	−0.055***	0.29***	−0.072
	(0.02)	(0.02)	(0.06)	(0.10)
Presecondary completed[a,c]	0.0061	−0.066***	0.37***	0.14
	(0.03)	(0.02)	(0.08)	(0.15)
Secondary completed[a,c]	0.0078	−0.10***	0.42***	−0.062
	(0.02)	(0.02)	(0.07)	(0.12)
University completed[a,c]	−0.038	−0.15**	0.37***	0.50**
	(0.07)	(0.06)	(0.13)	(0.21)
Income				
Consumption quintile 2[a,d]	−0.043*	0.022	0.19**	0.37**
	(0.02)	(0.02)	(0.09)	(0.15)
Consumption quintile 3[a,d]	−0.14***	0.12***	0.16**	0.51***
	(0.02)	(0.02)	(0.08)	(0.15)
Consumption quintile 4[a,d]	−0.19***	0.13***	0.32***	0.75***
	(0.02)	(0.02)	(0.09)	(0.14)
Consumption quintile 5[a,d]	−0.20***	0.10***	0.48***	0.88***
	(0.03)	(0.03)	(0.09)	(0.15)
Location				
Rural household[a,e]	0.24***	−0.15***	−0.27***	0.022
	(0.02)	(0.01)	(0.04)	(0.08)
Gender and wealth				
Female-headed household × consumption quintile 2	0.088	−0.071	−0.047	−0.83**
	(0.06)	(0.06)	(0.23)	(0.42)
Female-headed household × consumption quintile 3	0.057	−0.086	0.0094	−0.51
	(0.06)	(0.06)	(0.24)	(0.46)
Female-headed household × consumption quintile 4	0.075	−0.077	−0.018	−0.56
	(0.06)	(0.05)	(0.24)	(0.43)
Female-headed household × consumption quintile 5	0.074	−0.046	−0.11	−0.69
	(0.06)	(0.05)	(0.22)	(0.44)
Regions				
Region 2 (Manatuto, Manufahi, Ainaro)[a,f]	0.38***	−0.34***	−0.12**	−0.065
	(0.02)	(0.02)	(0.06)	(0.16)
Region 3 (Dili, Aileu, Ermera)[a,f]	0.23***	−0.11***	−0.57***	−0.38***
	(0.02)	(0.02)	(0.06)	(0.14)
Region 4 (Bobonaro, Cova Lima, Liquiçá)[a,f]	0.27***	−0.15***	−0.35***	0.11
	(0.02)	(0.02)	(0.06)	(0.13)
Region 5 (Oecusse)[a,f]	0.10***	0.064***	−0.68***	0.92***
	(0.02)	(0.02)	(0.05)	(0.12)

Continued.

Table 5. *Continued.*

Dependent variables	Share of expenditure on kerosene	Share of expenditure on fuelwood	Share of expenditure on electricity	Share of expenditure on other fuels
Constant	0.12	0.81***	−1.64***	−3.18***
	(0.08)	(0.08)	(0.28)	(0.58)
Sigma	0.35***	0.34***	0.77***	0.80***
	(0.01)	(0.01)	(0.03)	(0.06)
No. of observations	4,357	4,357	4,357	4,357
Left-censored observations at tker_exp <= 0	1,093	639	3,345	4,135
Uncensored observations	3,264	3,718	1,012	222
Right-censored observations	0	0	0	0
Pseudo R^2	0.21	0.16	0.10	0.19
F	44.04	30.90	25.80	10.93
Prob. > F	0.00	0.00	0.00	0.00
Log pseudolikelihood	−89,439.94	−83,897.11	−78,432.60	−20,503.39

[a]Dummy variables
[b]Excluded category: male-headed households
[c]Excluded category: household head with no education
[d]Excluded category: consumption quintile 1
[e]Excluded category: urban households
[f]Excluded region: Region I: (Baucau, Lautém, Viqueque)
Notes: Robust standard errors in parentheses. *** = 1% level of significance, ** = 5% level of significance, * = 10% level of significance.
Source: Authors' calculations.

expenditure on kerosene, indicating that rural households are more dependent on kerosene than urban households. The coefficients of the rural dummy, however, are −0.15 and −0.27, respectively, for fuelwood and electricity (both are significant at the 1% level), indicating that fuelwood and electricity are less important as sources of energy to rural households than urban households.

The regional dummies included in Table 5 show that compared with Region 1, households in all other regions are more likely to depend on kerosene and less likely to depend on wood and electricity.

3. Sensitivity Analysis

In Tables 6 and 7, we apply the same estimation methods (multivariate probit for estimating the energy choice function and Tobit for estimating the expenditure share function) to reestimate the functions by using different combinations of the samples. Table 6 presents estimated functions applying a multivariate probit model explaining household choices of different energy sources. In the first segment of Table 6, we include 75% of total sampled households (3,267 out of 4,357). In the second segment, we include 50% (2,178) of total sampled households. In the third segment, we include 25% (1,089) of total sampled households.

Table 6. **Multivariate Probit Model Explaining the Household Energy Choices of 75%, 50%, and 25% of Total Sampled Households**

Data Segment	75%				50%				25%			
Dependent variable: Energy sources	Kerosene	Fuelwood	Electricity	Other Fuels	Kerosene	Fuelwood	Electricity	Other Fuels	Kerosene	Fuelwood	Electricity	Other Fuels
Demographics												
Age, household head	0.005	−0.02	0.05**	0.070**	0.0033	−0.044**	0.041*	0.059	0.007	0.038	0.066**	0.11*
	(0.02)	(0.02)	(0.02)	(0.04)	(0.02)	(0.02)	(0.02)	(0.05)	(0.03)	(0.03)	(0.03)	(0.06)
Age squared, household head	−0.0001	0.0001	−0.0004**	−0.00084**	−0.000077	0.00043**	−0.00035	−0.00078*	−0.0001	−0.00048*	−0.00054*	−0.0012*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Female-headed household[a,b]	0.07	0.83***	0.09	0.51	0.85**	0.97***	−0.12	0.98*	−0.71**	0.65	0.39	−4.22***
	(0.25)	(0.25)	(0.26)	(0.51)	(0.38)	(0.31)	(0.39)	(0.56)	(0.36)	(0.42)	(0.37)	(0.39)
Household size (no. of family members)	−0.05***	0.09***	0.10***	0.079***	−0.049***	0.10***	0.082***	0.083***	−0.05**	0.076**	0.11***	0.077*
	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.04)	(0.03)	(0.04)
Human capital												
Primary completed[a,c]	−0.20**	−0.16	0.46***	−0.015	−0.24**	−0.071	0.46***	−0.098	−0.15	−0.40**	0.59***	0.30
	(0.09)	(0.10)	(0.10)	(0.15)	(0.11)	(0.12)	(0.12)	(0.18)	(0.15)	(0.17)	(0.16)	(0.26)
Presecondary completed[a,c]	−0.09	0.030	0.67***	0.070	−0.080	0.025	0.69***	0.24	−0.088	−0.019	0.69***	−0.45
	(0.12)	(0.14)	(0.13)	(0.20)	(0.16)	(0.18)	(0.16)	(0.22)	(0.21)	(0.24)	(0.21)	(0.33)
Secondary completed[a,c]	−0.23**	−0.33***	0.72***	−0.20	−0.30**	−0.32**	0.73***	−0.37	−0.10	−0.37*	0.75***	0.035
	(0.11)	(0.12)	(0.11)	(0.18)	(0.14)	(0.15)	(0.14)	(0.25)	(0.19)	(0.20)	(0.19)	(0.28)
University completed[a,c]	−0.45**	−0.69**	0.46**	0.48	−0.50*	−0.87**	0.39	0.26	−0.44	−0.37	0.65*	1.14**
	(0.23)	(0.29)	(0.20)	(0.33)	(0.30)	(0.36)	(0.24)	(0.45)	(0.34)	(0.53)	(0.34)	(0.48)
Income												
Consumption quintile 2[a,d]	0.11	0.29***	0.18	0.44**	0.24	0.46***	0.20	0.45	−0.089	−0.095	0.037	0.30
	(0.12)	(0.11)	(0.13)	(0.22)	(0.15)	(0.13)	(0.16)	(0.28)	(0.21)	(0.19)	(0.22)	(0.33)
Consumption quintile 3[a,d]	−0.07	0.53***	0.20	0.77***	0.073	0.64***	0.096	0.78***	−0.31	0.28	0.41*	0.58*
	(0.12)	(0.12)	(0.13)	(0.20)	(0.15)	(0.14)	(0.17)	(0.27)	(0.20)	(0.22)	(0.22)	(0.30)
Consumption quintile 4[a,d]	−0.37***	0.60***	0.58***	0.98***	−0.25*	0.75***	0.61***	1.19***	−0.59***	0.30	0.43*	0.59*
	(0.12)	(0.13)	(0.14)	(0.22)	(0.15)	(0.16)	(0.17)	(0.28)	(0.20)	(0.21)	(0.24)	(0.32)
Consumption quintile 5[a,d]	−0.31**	0.73***	0.85***	1.23***	−0.19	0.82***	0.79***	1.68***	−0.51**	0.59**	0.89***	0.34
	(0.14)	(0.16)	(0.15)	(0.22)	(0.17)	(0.20)	(0.18)	(0.28)	(0.22)	(0.24)	(0.24)	(0.35)

Continued.

Table 6. *Continued.*

Data Segment	75%				50%				25%			
Dependent variable: Energy sources	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**
Location												
Rural household	0.81***	−0.42***	−0.51***	0.044	0.90***	−0.38***	−0.52***	0.18	0.63***	−0.52***	−0.48***	−0.14
	(0.07)	(0.08)	(0.08)	(0.12)	(0.09)	(0.09)	(0.10)	(0.16)	(0.12)	(0.13)	(0.13)	(0.18)
Gender and wealth												
Female-headed household × consumption quintile 2	−0.33	−0.73**	0.30	−0.88	−1.31***	−0.95**	0.51	−0.97	0.94*	−0.37	0.28	−0.68
	(0.33)	(0.32)	(0.32)	(0.61)	(0.46)	(0.39)	(0.44)	(0.69)	(0.51)	(0.57)	(0.52)	(0.56)
Female-headed household × consumption quintile 3	−0.45	−0.91***	0.0041	−0.62	−1.28***	−1.14***	0.35	−1.62**	0.44	−0.50	−0.76	4.40***
	(0.32)	(0.34)	(0.33)	(0.67)	(0.45)	(0.40)	(0.46)	(0.76)	(0.53)	(0.59)	(0.51)	(0.69)
Female-headed household × consumption quintile 4	0.047	−0.83**	−0.19	−1.07*	−0.64	−0.98**	−0.055	−1.66**	0.73	−0.69	−0.23	3.96***
	(0.31)	(0.34)	(0.36)	(0.60)	(0.44)	(0.42)	(0.48)	(0.70)	(0.48)	(0.58)	(0.58)	(0.69)
Female-headed household × consumption quintile 5	−0.28	−0.64**	−0.28	−0.99	−1.10**	−0.80**	−0.19	−1.47**	0.51	−0.52	−0.29	3.75***
	(0.30)	(0.32)	(0.31)	(0.65)	(0.44)	(0.39)	(0.45)	(0.75)	(0.46)	(0.56)	(0.46)	(0.67)
Region												
Region 2 (Manatuto, Manufahi, Ainaro)[a,f]	1.29***	−0.71***	−0.42***	0.049	1.27***	−0.69***	−0.28**	−0.21	1.33***	−0.80***	−0.68***	0.35
	(0.11)	(0.10)	(0.10)	(0.21)	(0.13)	(0.12)	(0.12)	(0.26)	(0.19)	(0.17)	(0.17)	(0.37)
Region 3 (Dili, Aileu, Ermera)[a,f]	0.87***	−0.20**	−1.03***	−0.47**	0.83***	−0.20	−0.92***	−0.46**	0.90***	−0.22	−1.33***	−1.01***
	(0.09)	(0.10)	(0.11)	(0.19)	(0.11)	(0.13)	(0.14)	(0.21)	(0.15)	(0.18)	(0.19)	(0.30)
Region 4 (Bobonaro, Cova Lima, Liquiça)[a,f]	1.21***	0.20*	−0.79***	0.24	1.25***	0.30**	−0.77***	−0.17	1.17***	0.031	−0.87***	0.71**
	(0.11)	(0.11)	(0.11)	(0.19)	(0.13)	(0.14)	(0.14)	(0.24)	(0.17)	(0.17)	(0.19)	(0.34)
Region 5 (Oecusse)[a,f]	1.60***	0.93***	−0.90***	1.43***	1.55***	0.89***	−0.79***	1.57***	1.73***	1.09***	−1.13***	1.32***
	(0.17)	(0.20)	(0.09)	(0.19)	(0.21)	(0.24)	(0.11)	(0.20)	(0.22)	(0.26)	(0.17)	(0.42)

Continued.

Table 6. *Continued.*

Data Segment	**75%**				**50%**				**25%**			
Dependent variable: Energy sources	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**
Constant	−0.23	1.16***	−2.56***	−4.60***	−0.30	1.57***	−2.33***	−4.47***	−0.057	0.53	−3.11***	−5.34***
	(0.41)	(0.42)	(0.46)	(0.81)	(0.51)	(0.51)	(0.56)	(1.02)	(0.72)	(0.75)	(0.73)	(1.31)
atrho21	0.027				0.056				0.011			
	(0.05)				(0.06)				(0.08)			
atrho31	−0.57***				−0.58***				−0.50***			
	(0.05)				(0.06)				(0.09)			
atrho41	−0.015				0.099				0.00014			
	(0.09)				(0.11)				(0.18)			
atrho32	−0.30***				−0.31***				−0.36***			
	(0.05)				(0.06)				(0.08)			
atrho42	−0.21**				−0.20**				−0.25**			
	(0.09)				(0.10)				(0.12)			
atrho43	0.10				0.11				0.073			
	(0.07)				(0.09)				(0.13)			
No. of observations	3,267				2,178				1,089			
Walt Chi^2 (84)	1,260.32				1,074.14				1,806.16			
Prob. > chi^2	0.00				0.00				0.00			
Log pseudolikelihood	−174,289.56				−114,358.53				−57,630.37			

[a]Dummy variables
[b]Excluded category: male-headed households
[c]Excluded category: household head with no education
[d]Excluded category: consumption quintile 1
[e]Excluded category: urban households
[f]Excluded region: Region I: (Baucau, Lautém, Viqueque)
Notes: Robust standard errors in parentheses. *** = 1% level of significance, ** = 5% level of significance, * = 10% level of significance.
Source: Authors' calculations.

Table 7. **Two-Limit Tobit Model Explaining the Expenditure Share of Different Energy Sources of 75%, 50%, and 25% of Total Sampled Households**

Data Segment	75%				50%				25%			
Dependent variable: Energy sources	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**
Demographics												
Age, household head	0.00097	−0.0071*	0.042***	0.053**	0.0017	−0.0094**	0.053***	0.061**	0.00082	−0.0040	0.023	0.039***
	(0.00)	(0.00)	(0.01)	(0.03)	(0.00)	(0.00)	(0.02)	(0.03)	(0.01)	(0.01)	(0.02)	(0.00)
Age squared, household head	−0.0000062	0.000054	−0.00035***	−0.00069**	−0.000015	0.000075*	−0.00044***	−0.00074**	−0.0000049	0.000032	−0.00021	−0.00063***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Female-headed household[a,b]	−0.14***	0.11***	0.094	0.073	−0.14***	0.099**	0.15	0.068	−0.15**	0.14	0.00017	−3.14***
	(0.04)	(0.04)	(0.20)	(0.27)	(0.05)	(0.04)	(0.23)	(0.28)	(0.07)	(0.09)	(0.37)	(0.05)
Household size (no. of family members)	−0.033***	0.022***	0.039***	0.073***	−0.033***	0.023***	0.039***	0.074***	−0.033***	0.020***	0.031*	0.073***
	(0.00)	(0.00)	(0.01)	(0.02)	(0.00)	(0.00)	(0.01)	(0.03)	(0.01)	(0.01)	(0.02)	(0.01)
Human capital												
Primary completed[a,c]	−0.0062	−0.059***	0.31***	−0.046	0.0010	−0.083***	0.41***	0.038	−0.023	−0.0058	0.12	−0.39***
	(0.02)	(0.02)	(0.07)	(0.11)	(0.03)	(0.02)	(0.08)	(0.12)	(0.04)	(0.04)	(0.12)	(0.03)
Presecondary completed[a,c]	0.0065	−0.076***	0.42***	0.17	0.0080	−0.093***	0.53***	0.17	−0.0026	−0.037	0.21	0.15***
	(0.03)	(0.03)	(0.09)	(0.16)	(0.04)	(0.04)	(0.12)	(0.19)	(0.05)	(0.04)	(0.13)	(0.04)
Secondary completed[a,c]	0.014	−0.12***	0.50***	−0.062	0.030	−0.15***	0.54***	−0.063	−0.025	−0.066	0.47***	−0.100***
	(0.03)	(0.03)	(0.08)	(0.13)	(0.03)	(0.03)	(0.11)	(0.15)	(0.05)	(0.04)	(0.12)	(0.03)
University completed[a,c]	−0.057	−0.13*	0.44***	0.29	0.014	−0.22**	0.66***	0.35	−0.17	0.010	0.17	0.18***
	(0.09)	(0.07)	(0.14)	(0.22)	(0.11)	(0.09)	(0.19)	(0.26)	(0.14)	(0.10)	(0.22)	(0.04)
Income												
Consumption quintile 2[a,d]	−0.053**	0.051*	0.073	0.32**	−0.062*	0.059*	0.10	0.34*	−0.031	0.035	−0.010	0.12***
	(0.03)	(0.03)	(0.10)	(0.16)	(0.03)	(0.03)	(0.12)	(0.19)	(0.05)	(0.05)	(0.16)	(0.03)
Consumption quintile 3[a,d]	−0.16***	0.15***	0.10	0.69***	−0.16***	0.14***	0.18*	0.56***	−0.16***	0.16***	−0.061	0.96***
	(0.03)	(0.03)	(0.09)	(0.16)	(0.03)	(0.03)	(0.11)	(0.17)	(0.05)	(0.05)	(0.15)	(0.05)
Consumption quintile 4[a,d]	−0.22***	0.16***	0.27***	0.78***	−0.23***	0.15***	0.40***	0.69***	−0.20***	0.16***	0.039	0.98***
	(0.03)	(0.03)	(0.09)	(0.17)	(0.03)	(0.03)	(0.11)	(0.20)	(0.05)	(0.05)	(0.16)	(0.03)
Consumption quintile 5[a,d]	−0.24***	0.14***	0.41***	0.93***	−0.26***	0.15***	0.52***	0.89***	−0.17***	0.11*	0.16	0.94***
	(0.03)	(0.03)	(0.10)	(0.18)	(0.04)	(0.04)	(0.12)	(0.21)	(0.06)	(0.06)	(0.17)	(0.03)
Location												
Rural household	0.24***	−0.14***	−0.32***	−0.023	0.25***	−0.16***	−0.25***	−0.031	0.22***	−0.10***	−0.43***	−0.037
	(0.02)	(0.02)	(0.05)	(0.08)	(0.02)	(0.02)	(0.06)	(0.10)	(0.03)	(0.03)	(0.09)	(0.04)

Continued.

Table 7. *Continued.*

Data Segment	75%				50%				25%			
Dependent variable: Energy sources	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**
Gender and wealth												
Female-headed household × consumption quintile 2	0.11* (0.06)	−0.11* (0.07)	0.013 (0.24)	−0.21 (0.36)	0.17** (0.08)	−0.15* (0.08)	−0.060 (0.30)	−0.28 (0.45)	0.056 (0.11)	−0.079 (0.12)	0.12 (0.42)	3.36*** (0.05)
Female-headed household × consumption quintile 3	0.033 (0.07)	−0.056 (0.07)	−0.076 (0.26)	−0.68* (0.41)	0.093 (0.08)	−0.11 (0.07)	0.13 (0.30)	−3.84 (3.00)	−0.059 (0.14)	0.013 (0.12)	−0.62 (0.43)	2.72*** (0.05)
Female-headed household × consumption quintile 4	0.10* (0.06)	−0.078 (0.06)	−0.20 (0.26)	−0.075 (0.37)	0.19*** (0.07)	−0.14** (0.07)	−0.22 (0.30)	0.078 (0.45)	−0.048 (0.10)	0.023 (0.11)	−0.15 (0.44)	2.89*** (0.06)
Female-headed household × consumption quintile 5	0.12** (0.06)	−0.075 (0.06)	−0.18 (0.24)	−0.57* (0.34)	0.15** (0.07)	−0.097 (0.07)	−0.15 (0.28)	−0.54 (0.37)	0.071 (0.11)	−0.028 (0.11)	−0.28 (0.42)	2.56*** (0.04)
Region												
Region 2 (Manatuto, Manufahi, Ainaro)[a,f]	0.38*** (0.03)	−0.34*** (0.03)	−0.14** (0.07)	−0.036 (0.17)	0.37*** (0.03)	−0.36*** (0.03)	−0.085 (0.09)	−0.15 (0.22)	0.39*** (0.05)	−0.27*** (0.05)	−0.28** (0.12)	0.086** (0.04)
Region 3 (Dili, Aileu, Ermera)[a,f]	0.24*** (0.03)	−0.11*** (0.02)	−0.61*** (0.07)	−0.36** (0.15)	0.23*** (0.03)	−0.10*** (0.03)	−0.65*** (0.08)	−0.37** (0.17)	0.25*** (0.05)	−0.099** (0.04)	−0.56*** (0.11)	−0.39*** (0.05)
Region 4 (Bobonaro, Cova Lima, Liquiçá)[a,f]	0.28*** (0.03)	−0.14*** (0.02)	−0.40*** (0.07)	−0.079 (0.15)	0.28*** (0.03)	−0.14*** (0.03)	−0.48*** (0.09)	−0.010 (0.17)	0.28*** (0.04)	−0.14*** (0.04)	−0.28** (0.12)	−0.28*** (0.05)
Region 5 (Oecusse)[a,f]	0.11*** (0.02)	0.077*** (0.02)	−0.71*** (0.06)	0.91*** (0.10)	0.080*** (0.03)	0.092*** (0.03)	−0.68*** (0.07)	0.92*** (0.12)	0.14*** (0.04)	0.074** (0.04)	−0.80*** (0.10)	0.86*** (0.03)
Constant	0.17* (0.10)	0.80*** (0.09)	−1.92*** (0.33)	−3.36*** (0.64)	0.16 (0.12)	0.87*** (0.11)	−2.40*** (0.41)	−3.55*** (0.76)	0.16 (0.17)	0.66*** (0.16)	−0.99* (0.53)	−2.83*** (0.05)
Sigma	0.34*** (0.01)	0.33*** (0.01)	0.76*** (0.03)	0.72*** (0.07)	0.34*** (0.01)	0.33*** (0.01)	0.77*** (0.04)	0.72*** (0.08)	0.35*** (0.01)	0.32*** (0.01)	0.72*** (0.05)	0.68*** (0.02)

Continued.

Table 7. *Continued.*

Data Segment	**75%**				**50%**				**25%**			
Dependent variable: Energy sources	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**	**Kerosene**	**Fuelwood**	**Electricity**	**Other Fuels**
No. of observations	3,267	3,267	3,267	3,267	2,178	2,178	2,178	2,178	1,089	1,089	1,089	1,089
Left-censored observations	830	467	2,492	3,102	537	320	1,666	2,070	293	147	826	1,032
Uncensored observations	2,437	2,280	775	165	1,641	1,858	512	108	796	924	263	57
Right-censored observations	0	0	0	0	0	0	0	0	0	0	0	0
Pseudo R^2	0.23	0.18	0.11	0.24	0.24	0.19	0.13	0.24	0.24	0.16	0.11	0.30
Log pseudolikelihood	−64,999.91	−60,081.08	−57,399.60	−13,245.91	−42,546.44	−40,162.23	−37,289.00	−8,909.91	−21,837.43	−19,138.43	−19,360.31	−3,996.55

[a]Dummy variables
[b]Excluded category: male-headed households
[c]Excluded category: household head with no education
[d]Excluded category: consumption quintile 1
[e]Excluded category: urban households
[f]Excluded region: Region I: (Baucau, Lautém, Viqueque)
Notes: Robust standard errors in parentheses. *** = 1% level of significance, ** = 5% level of significance, * = 10% level of significance.
Source: Authors' calculations.

The first segment of Table 6, which includes 75% of total sampled households, clearly supports both of our hypotheses (1 and 2) that relatively affluent households are less likely to choose kerosene and more likely to choose wood and electricity as their sources of energy for domestic use. The middle segment, which includes 50% of total sampled households, and the last segment, which includes only 25% of total sampled households, also both support hypothesis (1). The estimated functions in Table 6 confirm that households progressively choose clean energy such as electricity as the level of education of the household head rises. The results in Table 6 are similar to those in Table 4 with respect to both the sign and the size of the coefficients. Even the influence of other variables such as the coefficient of the rural household dummy behaves the same during sensitivity tests as in the original estimation shown in Table 4.

In Table 7, we presented estimated functions applying a Tobit model to explain household expenditure shares on different energy sources. Similar to Table 5, we estimated the function first using 75% of total sampled households, and subsequently by using 50% and 25% of total sampled households. In each segment, the estimated results clearly show that household heads with higher levels of education spend relatively less on kerosene and wood and significantly more on cleaner energy such as electricity. Table 7 also demonstrates that relatively affluent households spend less on kerosene and more on electricity. The sensitivity analyses in Tables 6 and 7 support hypotheses (1) and (2); that is, more educated and affluent households, respectively, are more likely to use and spend more on electricity than other energy sources such as kerosene. In Tables 6 and 7, the observed behavior of relatively rich and female-headed households in choosing fuel sources and their relative dependency in terms of expenditure allocated to these fuel sources is consistent across the estimated functions using different data segments. These findings are also consistent with our observations from Tables 4 and 5.

Finally, the regional dummies are consistent across the estimated functions for different data segments in Tables 6 and 7, which is similar to our observations from Tables 4 and 5, indicating the robustness of the findings in these tables.

V. Conclusions and Policy Recommendations

This study uses data from the TLSLS 2007 to analyze household energy choices and dependency. In Timor-Leste, a significant proportion of the population use kerosene and fuelwood, while a smaller number of households use electricity. We found that only about 23% of total sampled households use electricity. Access to electricity among rural households is particularly limited. Only about 12% of sampled rural households were connected to the electric grid in 2007, compared with about 37% of sampled urban households.

Applying a multivariate probit model, this paper first explains the factors that affect the energy choices of households in Timor-Leste. Econometric results reveal that household characteristics such as the sex of the household head, the number of family members, the level of education of the household head, and income play an important role in the choice to use clean energy such as electricity. Our findings show that with an increase in the level of education of the household head, the probability of using electricity, which is a clean energy compared with kerosene and other fuel sources, increases progressively and the probability of using kerosene and fuelwood decreases progressively. Household wealth also affects energy choices as wealthier households are more likely to use clean energy and relatively poorer households are more likely to use kerosene.

The Tobit model, which identifies household dependency on a particular source of energy by measuring a household's share of expenditure on it, also confirms that household heads with higher levels of education spend relatively more on electricity and less on kerosene, reflecting a greater dependency on clean energy. The Tobit estimation confirms that wealthier households are also more dependent on electricity; in contrast, poorer households are more dependent on kerosene. Due to a lack of access to electricity, rural households are less likely to use electricity and more likely to use kerosene and fuelwood. Our econometric results confirm the impact of females on energy choices as female-headed households are more likely to use fuelwood and spend a larger share of household energy expenditure on it. The opportunity cost of fuelwood collection, a burden which generally falls upon female household members, increases as female incomes rise. Therefore, income-generating activities targeting poor and rural females can reduce the use of and dependence on fuelwood. Furthermore, rural electrification efforts need to be expanded to ease barriers to access to clean energy, which implies a potentially significant role for donor agencies.

This study clearly demonstrates that as income and education levels increase households are more likely to opt for clean energy, as predicted by the energy ladder hypothesis. While markets can play a role in facilitating economic growth and meeting the demands of burgeoning populations in developing economies, international donor agencies should also work with domestic governments to ensure that an adequate supply of clean energy is available for all at affordable prices. This may not be an easy task given the current economic situation of many developing economies like Timor-Leste. Generating affordable electricity for all by supplying natural gas to households in a developing economy, for example, requires major long-term investments. The increased use of more energy-efficient fuelwood stoves or solar-based stoves are alternative options that could help households achieve a stepwise transition toward reliance upon more sustainable energy sources. Governments and nongovernmental organizations can raise environmental and public health awareness and supply such stoves at affordable prices with the help of international donor agencies.

International donor agencies should also invest in raising education levels in developing economies. As educated household heads are more aware of the negative impacts of the use of kerosene and fuelwood, enhancing education systems in resource-poor developing economies can reduce the number of people suffering the negative consequences of using biomass and other dirty energy sources. Furthermore, a reduction in the use of biomass as a fuel can also bring enormous positive improvements to soil health and the environment.

While this study demonstrates the relationship between income, human capital (education), and energy choices, such choices can also be influenced by other factors such as consistency in the supply of electricity, energy prices, and the types of food and cooking practices that are part of the local culture. A household's dependency on cleaner sources of energy such as electricity may not necessarily be the result of relatively higher purchasing power, but rather because of factors such as the price and availability of electricity. Future studies should focus on these issues in examining household energy choices in developing economies.

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Erratum

“Wage Differentials between Foreign Multinationals and Local Plants and Worker Quality in Malaysian Manufacturing” by Eric Ramstetter
Volume 31, Issue Number 2, page 70

The printed table has missing variable names on the left-hand side of the table. The table should appear as follows:

Table 6: **Multinational-Local Wage Differentials, Other Slope Coefficients, and Equation Indicators from Estimates of Equation (1) for all 17 Sample Industries Combined**

	Pooled OLS			**Random Effects**		
	Lagged	**Contemporaneous**		**Lagged**	**Contemporaneous**	
Slope coefficient variable, indicator	**2001–2004**	**2001–2004**	**2000–2004**	**2001–2004**	**2001–2004**	**2000–2004**
LKE = capital intensity	0.0242***	0.0329***	0.0338***	0.0183***	0.0360***	0.0367***
LO = output scale	0.1071***	0.1178***	0.1187***	0.1032***	0.1229***	0.1264***
SH = highly paid share of paid workers	0.0074***	0.0070***	0.0082***	0.0037***	0.0061***	0.0074***
S3 = highly educated share of all workers	0.0064***	0.0072***	0.0060***	0.0042***	0.0064***	0.0049***
S2 = moderately educated share of all workers	0.0011***	0.0011***	0.0005***	0.0006***	0.0007***	0.0001
SF = female share of paid workers	−0.0039***	−0.0035***	−0.0036***	−0.0032***	−0.0026***	−0.0025***
DF = MNE–local differential (ratio less 1)	0.0890***	0.0809***	0.0913***	0.0749***	0.0525***	0.0658***
R^2	0.5591	0.5735	0.5638	0.5454	0.5683	0.5579
Observations	21,671	26,855	34,491	21,671	26,855	34,491
Breusch-Pagan Test	–	–	–	8,254***	10,202***	14,135***

*** = significant at the 1% level, ** = significant at the 5% level, * = significant at the 10% level.
Note: Robust standard errors (clustered by plant for random effects) are used to account for potential heteroskedasticity. Results of the Breusch-Pagan Test (null of no random effects) is always rejected at the 1% level. These results come from estimates that also include year, industry, and region dummies. Full results including constants and coefficients on year, industry, and region dummies are available from the author.

Erratum

"Population Aging and Potential Growth in Asia"
by Keisuke Otsu and Katsuyuki Shibayama
Volume 33, Issue Number 2, pp. 56–73

1. The printed article contains inaccurate quantitative results due to a computational error. The corrections are indicated below in bold italics:

   - Page 71, paragraph 1
     "The model without demographic effects predicts an average annual growth rate of ***2.5%***, while the benchmark model predicts an average annual growth rate of ***2.3%***. The demographic effect through government consumption increases the average annual growth rate by ***0.06*** percentage points. The demographic effect through the labor income tax and productivity reduces the average annual growth rate by ***0.41*** percentage points and ***0.40*** percentage points, respectively. The model with all channels included reduces the growth rate by ***0.71*** percentage points."

   - Page 72, paragraph 2
     "Overall, the population aging effect will dominate, reducing the average annual economic growth rate by ***0.21*** percentage points below its potential."

2. The corresponding Table 3 and Figures 5a–5f are corrected as follows. In addition, the order of Figures 5c, 5d, and 5e in the printed article is incorrect. We have corrected the order below.

Corrected Table 3

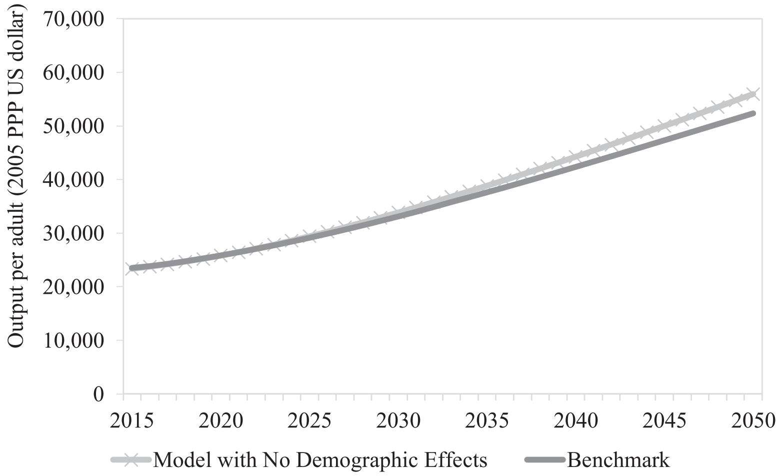
Table 3. **Average Annual GDP Per Adult Growth Rates**

Model	**Growth Rate**	**Difference from Benchmark** (percentage points)
No Demographic Effects	2.50%	0.21%
Benchmark	2.29%	–
with Government Consumption	2.35%	0.06%
with Labor Income Tax	1.88%	−0.41%
with Productivity	1.89%	−0.40%
with All Channels	1.58%	−0.71%

GDP = gross domestic product.
Source: Authors' calculations.

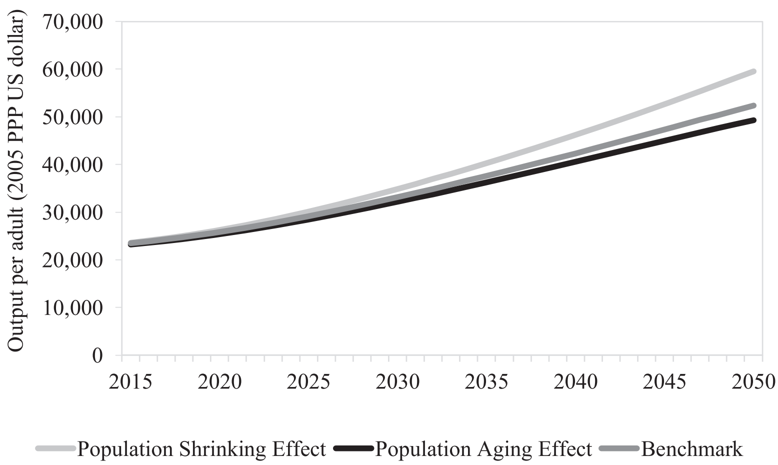
Corrected Figures 5a–5f

Figure 5a. **The Benchmark Model**



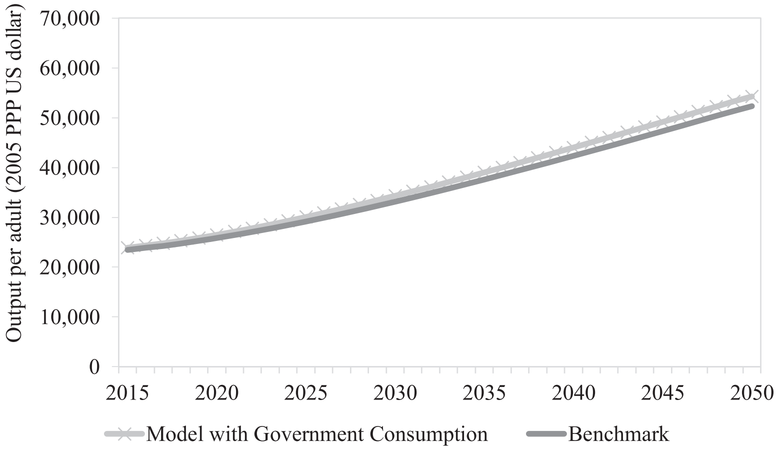
PPP = purchasing power parity, US = United States.
Source: Authors' calculations.

Figure 5b. **Demographic Effects**



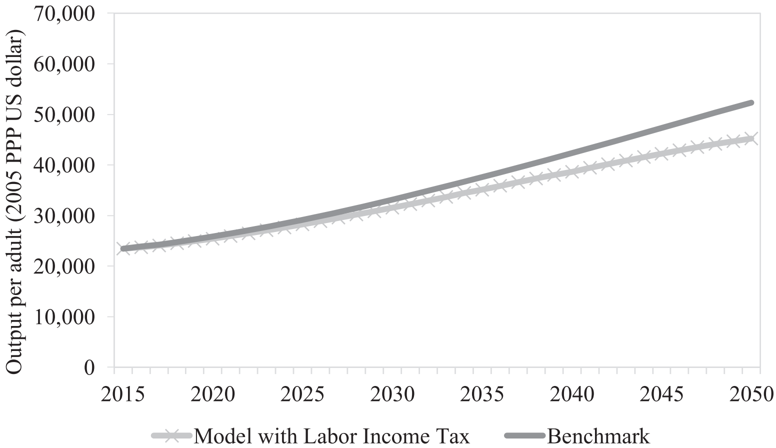
PPP = purchasing power parity, US = United States.
Source: Authors' calculations.

Figure 5c. **Model with Demographic Effect on Government Consumption**



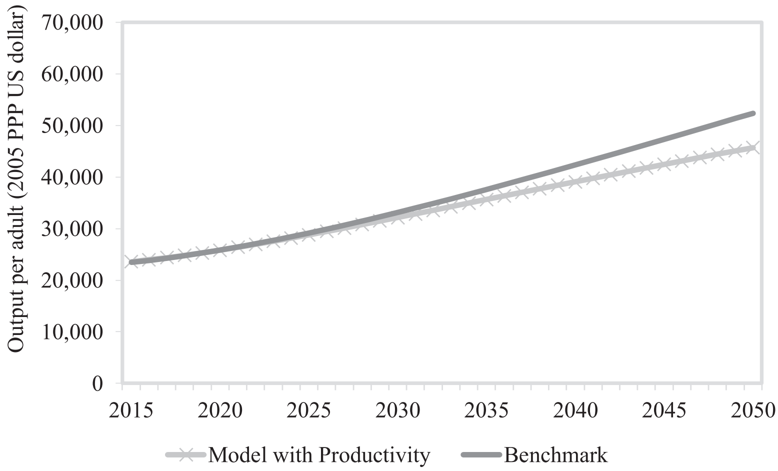
PPP = purchasing power parity, US = United States.
Source: Authors' calculations.

Figure 5d. **Model with Demographic Effect on Labor Income Tax**



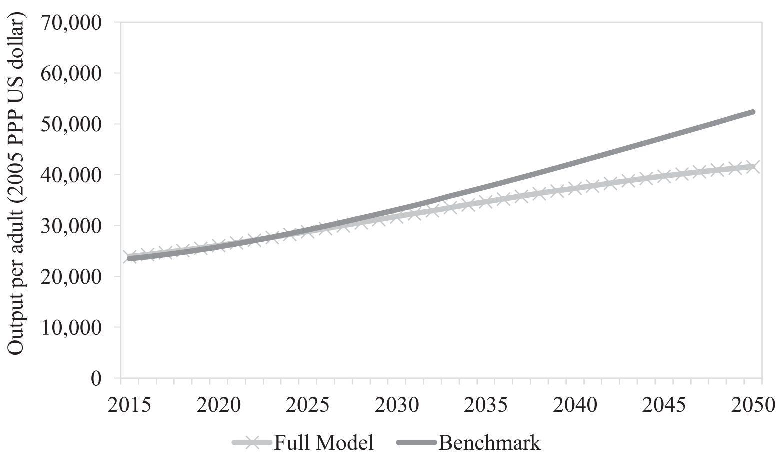
PPP = purchasing power parity, US = United States.
Source: Authors' calculations.

Figure 5e. **Model with Demographic Effect on Productivity**



PPP = purchasing power parity, US = United States.
Source: Authors' calculations.

Figure 5f. **Full Model**



PPP = purchasing power parity, US = United States.
Source: Authors' calculations.

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