The Productivity of Nations

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In this article, we document observations on labor productivity across countries over time. Using data from Heston, Summers, and Aten (2002) on gross domestic product (GDP) per worker—our measure of labor productivity—we emphasize three main facts about the distribution of labor productivity across countries between 1960 and 1996.[1] First, there is substantial dispersion in labor productivity across countries. For instance, in 1960 an average worker in the richest 5 percent of countries in the world produces about 35 times more output than an average worker in the poorest 5 percent of countries in the world.

Second, disparity in labor productivity has increased over time. By 1996, the labor productivity ratio between the richest and poorest countries increased to approximately 46. This increase in disparity is explained by a substantial deterioration in labor productivity in the poorest countries of the world relative to that of the United States. We report several statistics of dispersion indicating that labor productivity differences between the richest and poorest countries have increased since the mid-1980s. This characterization of increased dispersion in labor productivity contrasts with a relative stability documented in previous studies, in which the coverage period ended in 1985.

Third, there is substantial mobility of individual countries in the distribution of labor productivity over time. For instance, labor productivity in Hong Kong relative to that in the United States rose from 19 percent in 1960 to 94 percent in 1996—an increase of a factor of almost 5 during the period—while relative labor productivity in Venezuela declined from 94 percent in 1964 to 36 percent in 1996—a more than twofold drop in relative productivity. We also document a number of individual episodes of growth and decline. Ac-

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[1] Throughout the article, we refer to GDP per worker, output per worker, and labor productivity interchangeably.

counting for these specific labor productivity paths may prove useful not only from a policy perspective, but also in testing and improving existing theories of productivity levels or in the development of alternative theories.

This article relates to a large literature on the world distribution of income that includes Kaldor (1961), Kuznets (1966), Maddison (1995, 2001), Parente and Prescott (1993), Chari, Kehoe, and McGrattan (1996), Jones (1997), among many others. We contribute to this literature by adding the period between 1985 and 1996 to the analysis. In addition, we focus on output per worker as opposed to output per capita since output per worker relates more directly to theories of labor productivity. The difference between the two measures is given by the employment-to-population ratio. While there are substantial differences in these ratios across countries, the differences are not systematically related to development. Therefore, our summary statistics characterizing output per worker over time are similar to statistics calculated using output per capita. However, there are substantial changes in employment-to-population ratios for individual countries over time, and these changes are not systematically related to development or growth in relative productivity. Therefore, for an individual country, changes in output per capita can severely overstate or understate changes in labor productivity.

There are two additional differences between this article and the previous literature. First, we characterize disparity and mobility using trended data. That is, we use the Hodrick-Prescott filter to abstract from business-cycle fluctuations in the data. Second, we seek to systematically identify remarkable episodes of growth (positive or negative) in the data at some point during the 1960–1996 period. In the literature, countries facing these episodes are typically referred to as miracles and disasters. We document 13 miracle and 17 disaster episodes in our data set. Among the miracle episodes, we report the movement of labor productivity in Botswana relative to that in the United States from 7 percent to 30 percent in 26 years; in Hong Kong, from 19 percent to 94 percent in 36 years; and in China, from 4 percent to 8 percent in 18 years. We also document the recent, but not yet as long, growth episodes of Chile, Ireland, and India, which may become miracle episodes within the next two decades.

Furthermore, we also systematically document depression episodes in our panel data. Ever since the study of the Great Depression in the United States by Cole and Ohanian (1999), there has been substantial interest in studying depression episodes (defined broadly as periods of lower-than-usual relative productivity).[2] We follow this literature in characterizing depression episodes by using the raw data on output per worker relative to a trend growth of

[2] This marked interest is reflected, for instance, in the work of Prescott (2002) and in several articles published in a special volume of the *Review of Economic Dynamics* edited by T. Kehoe and E.C. Prescott (see Kehoe and Prescott 2002).

2 percent per year. Even in our relatively small sample period, we find that depressions are quite common, both among rich and poor countries. We report 29 depression episodes in Section 4.

Our study also relates to a broad literature on models that seek to explain development facts such as those of disparity and mobility discussed above. For excellent surveys of this literature see, for instance, Klenow and Rodríguez-Clare (1997) and Caselli (2005). Our study complements this literature by expanding and updating the set of facts that theories of development should be able to explain.

This article is organized as follows. In the next section, we describe in detail the data we use for the analysis. Section 2 documents the main facts about dispersion and mobility in the distribution of labor productivity. In Section 3, we discuss the remarkable episodes of growth during the period, namely miracle and disaster episodes, and in Section 4, we document the episodes of depressions. Section 5 discusses our main findings relative to those using instead output per hour, an alternative sample of countries, and output per capita. We conclude in Section 6.

1. DATA

We focus on output per worker as our measure of labor productivity. We use annual data on PPP-adjusted GDP per worker in chained 1996 prices obtained from Heston et al. (2002), also known as the Penn World Table V6.1 (PWT6.1). We choose the PWT6.1 for our analysis because it is the most comprehensive source of comparable measures of output per worker across countries.

We focus on output per worker in order to emphasize the connection of the data with research on productivity differences across countries. Although output per hour is a more complete measure of labor productivity, we abstract from differences in hours per worker across countries due to the lack of systematic data for a large number of countries over the entire period of our study. However, in Section 5, we use the available data on hours per worker to calculate output per hour and discuss our findings relative to this more complete measure of labor productivity. Measures of output per capita are appropriate when the focus is on wealth differences across countries.[3] We also discuss our findings relative to the use of output per capita in Section 5.

[3] Maddison (1995, 2001) documents comparable measures of output per capita for a wide range of countries and time periods. However, we note that, as in the PWT6.1, Maddison uses the detailed price data from the International Comparisons Project (ICP) of the United Nations to calculate purchasing power parity (PPP) conversion factors at a point in time, and national accounts data to extrapolate over time. In this sense, Maddison's output data is comparable to PWT6.1, especially for the Benchmark countries (see Section 5 for a definition of Benchmark countries).

Our data set consists of annual observations for 99 countries from 1960 to 1996.[4] The countries in our data set satisfy two restrictions. First, the total population of each country was at or above 1 million people in 1996. Second, data was available at each date from 1960 to 1996. We make this second restriction in order for the sample of countries to be constant throughout the period of analysis. Data is available for 48 countries from 1950 to 2000. However, countries without observations between 1950 and 1960 and between 1996 and 2000 tend to be poorer countries. Thus, the smaller sample from 1950 to 2000 is less representative of the world distribution of output per worker than our sample with 99 countries from 1960 to 1996.

In documenting observations about dispersion, mobility, and miracles and disasters, we abstract from business-cycle fluctuations and trend the data using the Hodrick-Prescott filter.[5] Abstracting from business-cycle fluctuations when reporting development facts is not innocuous. As we document in Section 4, countries undergo episodes of substantial growth and decline that are not entirely related to their development process. To illustrate the cycles in the annual data, we report in Figure 1 the raw data on output per worker and the trended data for four countries: the United States, Argentina, Romania, and Switzerland. As is true with many other countries in our panel data, these countries have undergone relatively short-lived variations in their output per worker at different points in time. Our documentation of the development facts abstracts from these fluctuations.

For the most part, we report statistics on output per worker relative to that of the United States. Our view is that the United States is a rich, stable, and diverse country. For most of the period of analysis, the United States had the highest labor productivity. Moreover, in the post-war period, (trended) labor productivity grew at roughly 2 percent per year. Therefore, the United States represents a good benchmark against which to measure potential gains in labor productivity in all countries.

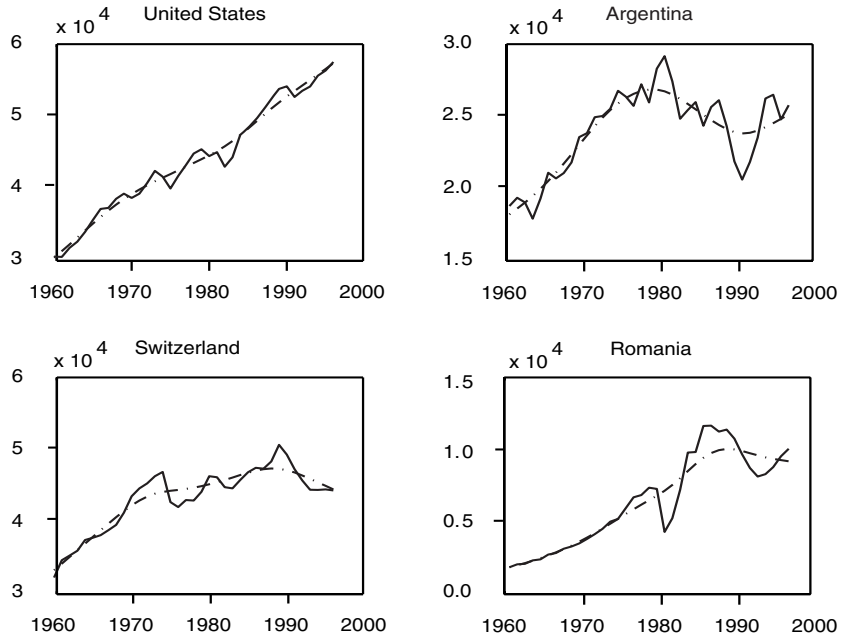
2. LABOR PRODUCTIVITY ACROSS COUNTRIES

We emphasize three facts about the distribution of labor productivity across countries. First, there is a large disparity in output per worker across countries. Second, there is a substantial increase in disparity over time. Third, there are substantial movements of individual countries in the world distribution of productivity. In the remainder of this section we characterize these facts in detail.

[4] See the Appendix for a list of countries in our data set.

[5] We set the smoothing parameter λ equal to 100.

Figure 1 Output per Worker in Four Countries



Notes: For each country, the solid line represents the raw data on output per worker and the dotted-dashed line the HP-trended data.

Disparity

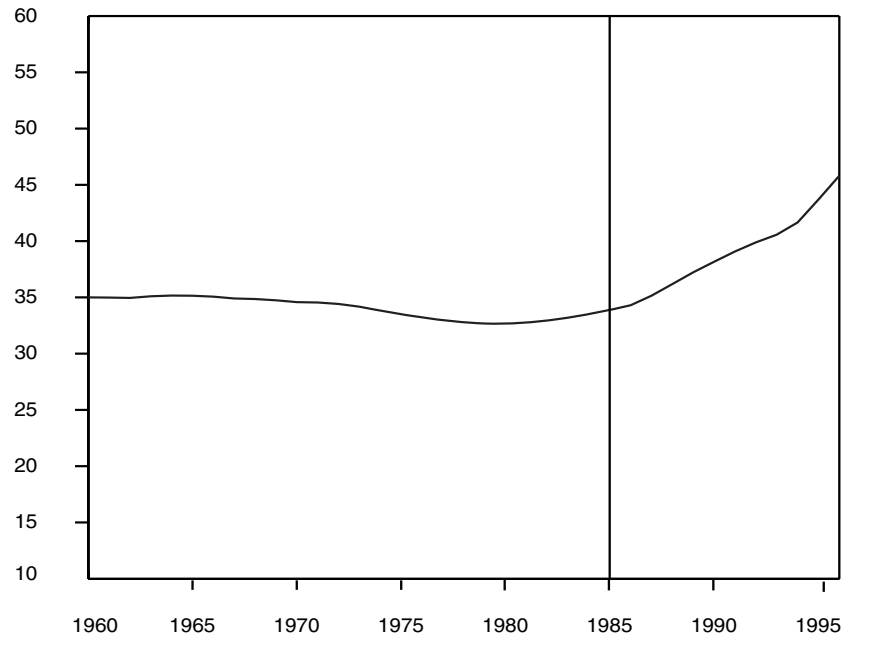
A remarkable fact of modern development data is the large disparity in productivity among countries. Here we focus on different measures of disparity and their evolution between 1960 and 1996.

We start by focusing on the five richest and five poorest countries in our sample. We compute the ratio of average output per worker for the five richest and five poorest countries for each year from 1960 to 1996, illustrated in Figure 2. This ratio varies between 35 and 46 over the period of analysis. That is, the average worker in the richest countries produces between 35 and 46 times more output than the average worker in the poorest countries. These are remarkable differences in labor productivity.

This measure of disparity in productivity across countries has been roughly constant from 1960, at 35, until the mid-1980s. The ratio declined slightly around 1980 but has increased steadily since then to a factor of 46 in 1996.[6]

[6] The ratio of average output per worker for the 5 richest and 5 poorest countries computed using the data set of 48 countries with data from 1950 to 2000 shows the same pattern as in

Figure 2 Output per Worker—Ratio of Five Richest to Five Poorest Countries



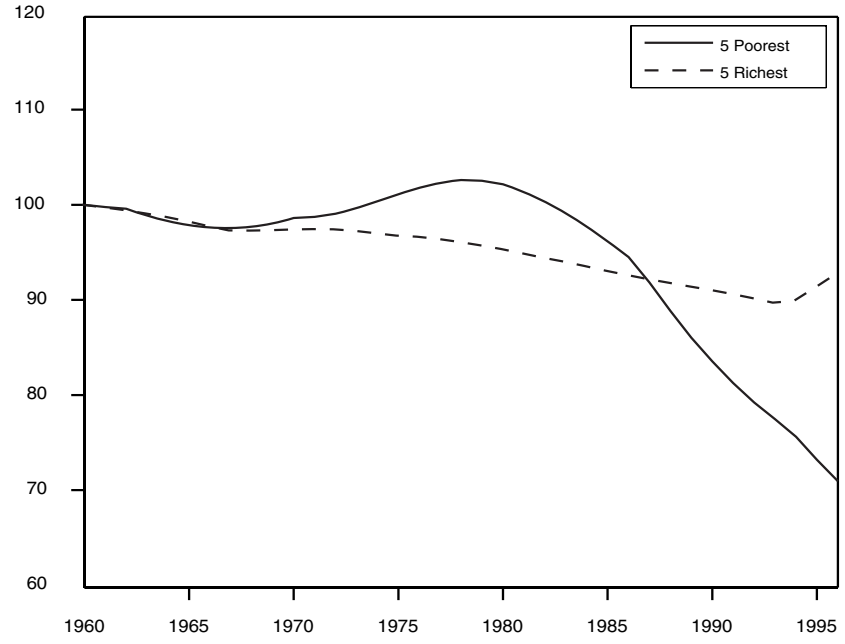
Notes: Between 1960 and 1996, the following countries comprised the five richest at some point in time: the United States, Switzerland, Canada, New Zealand, the Netherlands, Belgium, Italy, Norway, and Hong Kong. During the same period, the following countries comprised the five poorest countries at some point in time: Tanzania, Guinea Bissau, Burundi, Ethiopia, Burkina Faso, Uganda, and the Democratic Republic of Congo.

This increase in dispersion runs contrary to the established view in the development literature that dispersion in the world distribution of productivity has been rather constant over time (see, for instance, Parente and Prescott 1993; Chari, Kehoe, and McGrattan 1996). The reason for this view is that until about 1985 (the end date in most previous studies), the productivity ratio of the richest to the poorest countries was roughly constant. See Figure 2 where the line drawn at 1985 emphasizes the connection with the earlier literature.

In Figure 3 we report the relative productivity of the five poorest and five richest countries between 1960 and 1996, each normalized to 100 in

Figure 2. For this data set, the ratio of rich to poor increases steadily from the early 1980s to 2000.

Figure 3 Relative Output per Worker—Five Richest and Five Poorest (1960=100)



Notes: Average output per worker relative to the United States for the five richest and five poorest countries. Both series are normalized to 100 in 1960. In 1960, the average relative output per worker of the five poorest countries is 2.8 percent, while for the five richest countries, it is 99 percent.

1960.[7] This figure shows that the increase in dispersion in relative productivity between the richest and poorest countries reported in Figure 2 is mostly due to the decline in relative productivity of the five poorest countries. Between 1960 and 1996, relative productivity in the richest countries fell by about 10 percent, while relative productivity in the poorest countries fell by about 30 percent. It is of interest to note that even the five richest countries declined in productivity relative to that in the United States. Duarte and Restuccia (2006) show that the decline in productivity in the richest countries relative to that in the United States is accounted for by the movement of employment to the

[7] In 1960, the average output per worker of the five poorest countries relative to that of the United States is 2.8 percent, while the average of the five richest countries is 99 percent. By 1996, average relative labor productivity is 2 percent in the five poorest countries and 92 percent in the five richest countries.

Table 1 Relative Output per Worker by Decile

	1960	1970	1980	1990	1996
Deciles:			(percent)		
D1	3.4	3.3	3.4	2.8	2.4
D2	6.0	5.8	5.5	4.6	3.7
D3	7.8	7.9	7.7	6.4	5.4
D4	11.0	10.6	12.2	11.4	10.6
D5	16.7	18.1	20.1	17.8	17.4
D6	21.2	22.8	27.8	25.1	23.9
D7	27.2	32.8	34.5	31.7	32.5
D8	38.6	44.1	50.2	48.0	51.0
D9	56.6	65.3	70.2	69.5	72.7
D10	89.6	89.7	88.3	85.2	86.0
Ratios:					
D10/D1	26.3	27.1	25.9	30.9	35.6
D9/D2	9.5	11.3	12.7	15.2	19.6

Notes: Decile i (Di) includes countries within the $10 \times (i-1)$ and $10 \times i$ percent of the distribution.

service sector (associated with the process of structural transformation) and the low labor productivity in this sector relative to that in the United States.

We now focus on the entire distribution of labor productivity across countries. Table 1 reports the average relative output per worker of countries at each decile of the distribution of countries and for a selected number of years. The first decile includes the 10 percent of countries at the bottom of the distribution of output per worker, while the tenth decile includes the 10 percent of countries at the top of the distribution of output per worker. The last two rows report the ratio of the tenth decile to the first and the ratio of the ninth decile to the second.

In 1960, the poorest 10 percent of countries had an average labor productivity of around 3 percent of that of the United States, while the richest 10 percent of countries had an average productivity of 90 percent of that of the United States, yielding a ratio of 26 between the richest 10 percent to the poorest 10 percent of countries. In turn, for the same year, the ratio of productivity for countries in the ninth decile to the second decile is a factor of almost 10. Note that these ratios increase substantially during our period of analysis, but especially do so after 1980. Note also that, over time, countries in the sixth, seventh, eighth, and ninth deciles improved their average relative productivity (particularly those in the eighth and ninth deciles) while countries in the bottom five deciles and in the top decile had either fallen further behind or stagnated relative to that of the United States. These patterns indicate that increasing dispersion in relative labor productivity is occurring not only at the extremes of the distribution but also in the middle.

Table 2 Relative Output per Worker by Quintile

	1960	1970	1980	1990	1996
Quintiles:			(percent)		
Q1	4.7	4.5	4.5	3.7	3.1
Q2	9.4	9.3	10.0	8.9	8.0
Q3	19.1	20.7	24.1	21.6	20.8
Q4	34.1	39.9	43.8	41.8	43.8
Q5	74.5	78.7	80.4	78.0	80.0
Ratios:					
Q5/Q1	15.8	14.5	18.0	21.3	26.1
Q4/Q2	3.6	4.3	4.4	4.7	5.5

Notes: Quintile i (Qi) includes countries within the $20 \times (i-1)$ and $20 \times i$ percent of the distribution.

Disparity in relative productivity between rich and poor countries is apparent even for broader groups of countries. Table 2 reports the average relative output per worker by quintile. Even when the 20 richest and 20 poorest countries are averaged, dispersion in labor productivity is large (a ratio of 15.8 between these two sets of countries in 1960 and 26.1 in 1996), and the poorest countries have lost ground in productivity relative to the richest countries over time (from 4.7 percent of the United States in 1960 to 3.1 percent in 1996).

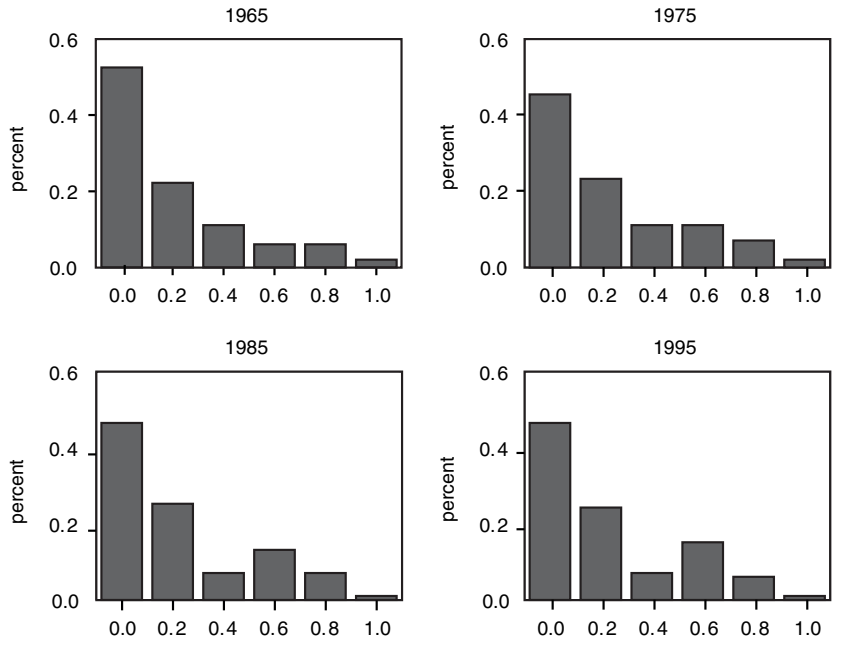
The disparity facts we have documented are supported by other summary statistics of dispersion. The Gini coefficient, for instance, is a commonly used measure of inequality. We compute the Gini coefficient for each year in our sample and we find that this statistic confirms our earlier findings.[8] The Gini coefficient was roughly constant (at about 0.49) until the early 1980s and it has increased since then (to about 0.52 in 1996).

Changes in the dispersion of relative labor productivity over time across countries suggest movements of individual countries in the distribution of productivity across countries over time. To document these changes, we report the histogram of the distribution of relative output per worker across countries at different points in time in Figure 4. The most noticeable change in the distribution from 1965 to 1995 is the movement of mass from the middle of the distribution to the right and to the left, creating what the literature calls "twin peaks" in the world distribution of relative output per worker.[9]

[8] We compute the Gini coefficient as $G = \frac{N}{N-1}\frac{\sum_{i=1}^{N}(2i-N-1)x_i}{N^2\mu}$, where x is an $N \times 1$ vector with the observations sorted in ascending order and μ is its mean. This coefficient varies between 0, reflecting complete equality and 1, which indicates complete inequality (all income is concentrated in only one country).

[9] See, for instance, Jones (1997).

Figure 4 Distribution of Relative Output per Worker



Notes: The bins in these histograms are defined as follows: $0 = [0, 0.2], 0.2 = [0.2, 0.4], 0.4 = [0.4, 0.6], 0.6 = [0.6, 0.8], 0.8 = [0.8, 1.0]$,and $1 = [1.0, 1.2]$.

Therefore, this statistic also captures an increase in the dispersion of relative productivity across countries.

We have presented statistics that capture an increase in the dispersion of labor productivity across countries, especially after the mid-1980s. This increase is relevant for theories of development because, in these theories, relative productivity levels are related to policies and institutional factors at the country level. We emphasize, however, that the observed increase in disparity in productivity does not necessarily imply an increase in income inequality in the world. There are at least three reasons. First, our disparity statistics do not adjust for changes in the employment-to-population ratios over time and in the size of population across countries. In particular, improvements in the standard of living in China and India alone (as we document later in this article) imply improvements in the standard of living for a sizeable portion of the population in the world (about 35 percent).[10] Second, our disparity statistics

[10] See, for instance, Bourguignon and Morrison (2002).

Table 3 Relative Output per Worker by Region

	1960	1970	1980	1990	1996
Asia	0.14	0.18	0.23	0.28	0.34
Latin America	0.34	0.35	0.35	0.28	0.25
Africa	0.12	0.13	0.14	0.12	0.12
Western Europe	0.62	0.71	0.77	0.75	0.75
Canada	0.92	0.90	0.88	0.83	0.79
Oceania	0.68	0.65	0.60	0.54	0.52

do not adjust for inequality within countries. Sala-i-Martin (2006) documents a reduction in global inequality in income per capita when including within-country inequality in the analysis. Third, our dispersion statistics do not capture improvements in broader notions of quantity and quality of life, such as improvements in life expectancy.[11]

In this section, we have documented that disparity in relative productivity across countries is large and that it has increased over the period of analysis. Below, we relate disparity in relative productivity with the geographical location of countries. We report substantial differences in labor productivity across regions in the world as well as substantial movements in these regional differences over time.

Table 3 reports averages of labor productivity by region for selected years. For instance, in 1960 the average labor productivity of the Asian countries in our data set was only 14 percent of that in the United States (about the same level of relative labor productivity in Africa) and 41 percent of that in Latin America. By 1996, Asia improved its position relative to that of the United States to 34 percent, surpassing both Latin America and Africa. On average, labor productivity in Africa did not improve relative to that in the United States (at roughly 12 percent). However, as we document below, this is a result of disparate experiences within Africa, with some countries declining in labor productivity both in absolute levels and relative to that of the United States, as well as with countries growing faster than the United States. In contrast, Latin America declined relative to the United States, from about 34 percent in 1960 to 25 percent in 1996. In the case of Latin America, the common path of relative labor productivity was one of decline, perhaps with the only exception being Chile, which started rapidly catching up to the United States in 1990. Countries in Western Europe had a relative productivity of 62 percent in 1960, experienced a period of relative fast gain to 77 percent in 1980, but have since stagnated relative to the United States to average levels of 75 percent. Canada,

[11] See, for instance, Becker et al. (2005).

Table 4 Mobility Matrix—Relative Output per Worker

		$t+20$				
		0-0.075	0.075-0.15	0.15-0.3	0.3-0.6	0.6-1.2
	0-0.075	0.86	0.11	0.03	0	0
	0.075-0.15	0.38	0.46	0.11	0.05	0
t	0.15-0.30	0.01	0.15	0.57	0.26	0.01
	0.3-0.6	0	0.02	0.22	0.48	0.28
	0.6-1.2	0	0	0	0.10	0.90

as well as countries in Oceania, had high relative labor productivity in 1960 but slowly declined relative to the United States.

Mobility

Associated with changes in the dispersion of relative labor productivity over time across countries is a substantial mobility of individual countries in the distribution of relative productivity over time. In the remainder of this section, we provide different characterizations of mobility in our data set. In the next two sections, we focus on individual country experiences.

To start, we characterize mobility in our data through two mobility matrices. The matrix in Table 4 reports the frequency of movements, defined over a period of 20 years, for relative productivity in our sample. We consider 5 bins for relative productivity, which imply a distribution of countries in 1960 that is roughly uniform. For each year since 1960, we ask how the position in relative productivity for a particular country changed in 20 years. Then we average all the experiences across countries and over time (all the 20-year windows from 1960 to 1996) in Table 4. For instance, the first element of this matrix, 0.86, is the average frequency with which countries with relative productivity between zero and 0.075 in a given year also have relative productivity between zero and 0.075 20 years later.

Mobility in Table 4 (as measured by the off-diagonal elements of the matrix) is higher in the middle of the relative productivity distribution than in its extremes. The diagonal elements of this matrix are substantially higher for the poorest countries (with relative productivity between zero and 0.075) and the richest countries (with relative productivity between 0.6 and 1.2), compared to diagonal elements for the other groups of countries. In addition, note that among middle-productivity countries (those with relative productivity between 0.075 and 0.6), most improvements in relative productivity in a span of 20 years have occurred for the richer countries in this subset, while most declines have occurred for the poorer countries. For instance, out of all countries with relative productivity between 0.075 and 0.15 at some year in our sample

Table 5 Mobility Matrix by Quintile

		$t+20$				
		Q1	Q2	Q3	Q4	Q5
	Q1	0.78	0.21	0.01	0	0
	Q2	0.22	0.64	0.11	0.03	0
t	Q3	0	0.14	0.62	0.24	0
	Q4	0	0.02	0.24	0.58	0.16
	Q5	0	0	0	0.16	0.84

Notes: Quintile i (Qi) includes countries within the $20 \times (i-1)$ and $20 \times i$ percent of the distribution of relative output per worker.

period, 20 years later, 46 percent of these countries remained in the same relative productivity bracket and 38 percent declined to a relative productivity between zero and 0.075. In contrast, for countries with relative productivity between 0.15 and 0.3, 20 years later, 57 percent remained in the same relative productivity bracket and 26 percent improved to a relative productivity between 0.3 and 0.6. This finding is consistent with the characterization of deciles in the previous subsection.

The matrix in Table 4 focuses on the mobility for relative productivity in our sample. In Table 5 we report an alternative mobility matrix constructed by quintile. In this matrix, the first element (0.78) represents the average frequency with which countries in the bottom quintile of the relative income distribution in a given year are also in the bottom quintile 20 years later. Note that this second mobility matrix focuses on mobility for the relative position of a country within the distribution. Therefore, unlike Table 4, this matrix does not provide direct information on changes in the level of average relative productivity of countries in a given bin.

The same basic patterns described for Table 4 also emerge in this second mobility matrix. In particular, mobility is lower for countries in the bottom and top quintiles than in the middle quintiles.

We can also characterize mobility by comparing the level of relative productivity of countries in 1960 and 1996. Figure 5 summarizes this information. In this figure, countries in the 45-degree line represent those in which productivity relative to that of the United States has not changed from 1960 to 1996. Recall that for countries on the 45-degree line, labor productivity grew at roughly 2 percent per year during the sample period. Countries above (below) the 45-degree line are those that have improved (deteriorated) their relative productivity.

Figure 5 Relative Output per Worker, 1960 vs. 1996 (log scale)

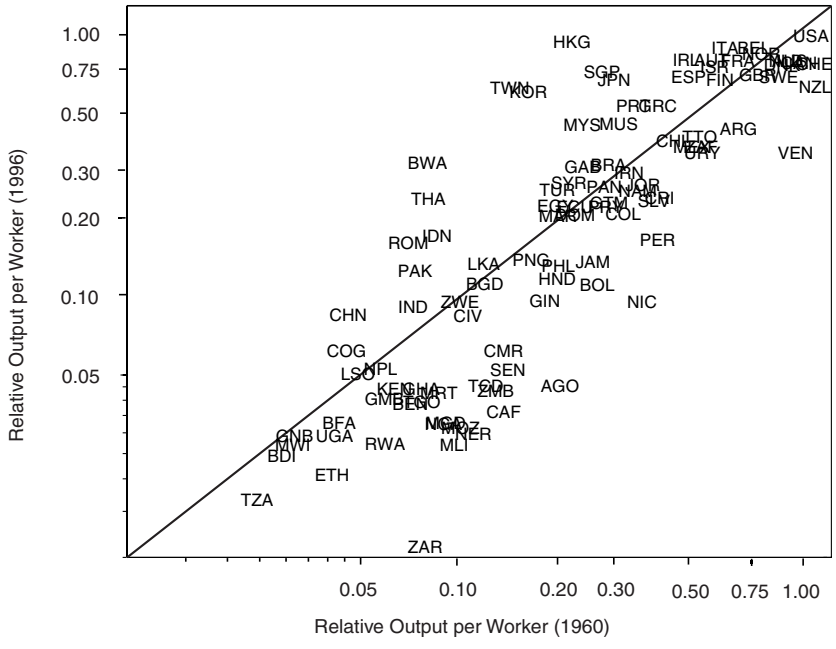


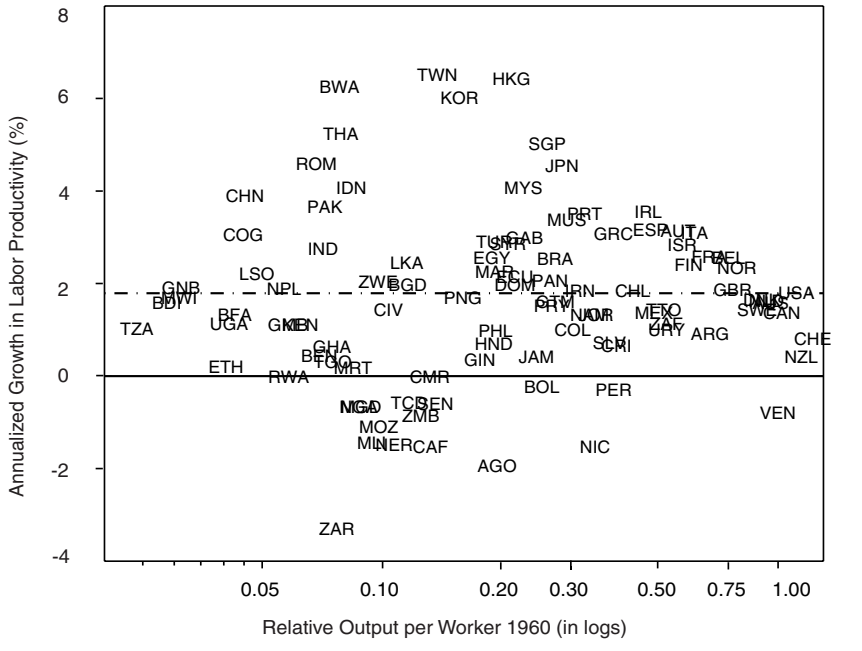
Figure 5 illustrates that individual countries have moved substantially in the distribution of relative labor productivity during this period. Particularly noticeable are the movements in relative productivity of countries such as Hong Kong, Taiwan, Korea, Botswana, the Democratic Republic of Congo, Angola, and Venezuela.[12]

Finally, a summary statistic of the performance of individual countries during the period from 1960 to 1996 is the annualized growth rate of output per worker. Figure 6 shows that there are important differences in this growth rate across countries.[13] Output per worker in several countries deteriorated relative to that in the United States. Countries that experienced this situation were both rich and poor in 1960. Relative rich countries that observed negative performances include New Zealand, Switzerland, Venezuela, Canada, Sweden, the Netherlands, and Argentina. The most notorious negative performers

[12] Using 1985 as the end year implies much less dispersion in relative productivity around the 45-degree line. This fact suggests that there were substantial movements in relative productivity between 1985 and 1996. Particularly noticeable are Thailand, China, Tanzania, and Ethiopia.

[13] Growth rate differences are not systematically related to the level of relative productivity in 1960. For a documentation of this finding, see, for instance, Mankiw, Romer, and Weil (1992) and Chari, Kehoe, and McGrattan (1996).

Figure 6 Growth in Output per Worker (1960–1996)



Notes: The dotted-dashed line is the annualized growth rate of output per worker between 1960 and 1996 in the United States.

of the poor countries in 1960 are Angola, Central African Republic, and the Democratic Republic of Congo in Africa, and Nicaragua, Peru, and Bolivia in Latin America. We find that in a surprisingly large number of countries, such as Venezuela, Nicaragua, and many African countries, output per worker fell in absolute terms from 1960 to 1996. The explanation for these disparate growth experiences is a fundamental question for future research.[14]

A large number of countries gained position in the distribution of relative output per worker. These included relatively rich countries in 1960, such as Ireland, Spain, Austria, Italy, France, Belgium, and Norway, as well as relatively poor countries, such as Taiwan, Hong Kong, Singapore, Japan, Botswana, Thailand, and Romania. Again, understanding the factors that explain these remarkable growth performances is of first-order importance in

[14] See some related work in Bello and Restuccia (2003); Cole, Ohanian, Riascos, and Schmitz (2005); Gollin, Parente, and Rogerson (2002); and Restuccia, Yang, and Zhu (2006).

development economics.[15] We note, however, that there may be other relevant growth experiences that are not captured by average growth because the experiences begin later than 1960. For instance, China, Ireland, and India are undergoing a miracle growth process that started later than 1960. In the next section, we study systematically remarkable growth experiences in the data.

3. MIRACLES AND DISASTERS

Within the period between 1960 and 1996, there have been substantial movements of individual countries over time in the distribution of relative output per worker. These movements are of interest because they provide opportunities and challenges to theories of development. Our documentation thus far has focused on countries with high and low annualized growth rates of output per worker during the entire period from 1960 to 1996. However, the time series of individual countries in output per worker show episodes of substantial positive and negative growth within this period. Therefore, growth as summarized by the growth rate in output per worker between 1960 and 1996 may hide interesting growth episodes that occur within this period. For this reason, we seek to systematically identify episodes of substantial and sustained growth or decline in relative productivity during our sample period.

For each country, we record a miracle or disaster episode if trended output per worker in a country relative to that of the United States grows or declines by more than 2 percent per year for at least 15 consecutive years. That is, a miracle episode is one in which output per worker grows at about 4 percent or more per year since trended output per worker in the United States grows at roughly 2 percent per year. Similarly, a disaster episode is one in which output per worker is stagnant or declines. Our view is that countries that are lagging behind the technology frontier should be able to double the growth rate of world knowledge in a miracle experience, while disaster experiences would feature no growth or decline in output per worker for a sustained period of time.

For each growth episode, we record the starting and ending years of the episode, the relative output per worker in the starting and ending years, and the implied annualized growth rate of relative output per worker during the episode. Tables 6 and 7 report the countries for which the recorded growth episodes satisfy the two conditions specified above for a miracle and a disaster. Notice that the changes in relative output reported in these tables focus only on the period of substantial growth or decline. However, for many of these countries, the process of growth or decline may have started earlier or continued later than reported but at lower rates. Moreover, many of the episodes

[15] See, for instance, Duarte and Restuccia (2006).

Table 6 Miracle Episodes

Country	Annualized Growth (%)	Start Year	Number of Years	Rel. Y/L Start	Rel. Y/L End
Botswana	5.59	1965	26	0.07	0.30
Gabon	4.90	1960	15	0.21	0.42
Romania	4.80	1960	25	0.06	0.20
Taiwan	4.64	1960	36	0.12	0.63
Japan	4.56	1960	16	0.26	0.53
Hong Kong	4.54	1960	36	0.19	0.94
Greece	4.46	1960	15	0.34	0.66
Korea	4.20	1961	35	0.14	0.61
Singapore	4.10	1960	23	0.23	0.59
China	3.94	1978	18	0.04	0.08
Rep. of Congo	3.84	1960	24	0.04	0.10
Indonesia	3.62	1969	15	0.07	0.12
Thailand	3.39	1960	36	0.07	0.24

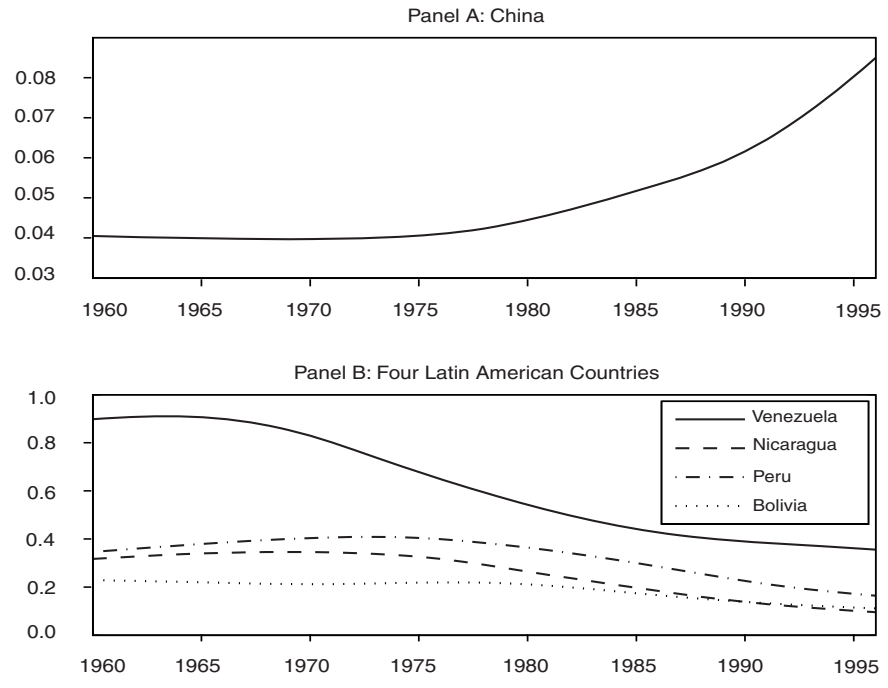
Notes: Annualized Growth is the growth rate in *relative* output per worker during the episode. To obtain an approximate annualized growth rate in output per worker, add 2 percent from growth in output per worker in the United States. Rel. Y/L is relative output per worker.

reported may be censored since the sustained process of growth or decline may have started before 1960 or may have continued after 1996.

As expected, Table 6 is composed mostly of Asian countries, such as Taiwan, Japan, Hong Kong, among others. Notice that in some of the episodes reported in this table, relative output per worker grew at an annualized rate greater than 4 percent. Given the long time span of the experiences, these countries improved their relative productivity dramatically. For instance, in Botswana, relative productivity increased from 7 percent in 1965 to 30 percent in 1991, and in Hong Kong, relative productivity increased by a factor of 5, from 19 percent in 1960 to 94 percent in 1996. Note that, excluding Hong Kong, these countries are still substantially below the level of U.S. labor productivity at the end of their miracle episode.

The latest miracle episode reported in Table 6 is China. Since 1978, labor productivity in China relative to that of the United States has grown at almost 4 percent per year, and by 1996, China doubled its relative productivity to 8 percent (see Figure 7, Panel A). However, this sustained period of growth in productivity relative to that of the United States did not start until 1978; before then, relative labor productivity was slightly declining or stagnant. While China is undergoing a sustained period of growth, its growth performance between 1978 and 1996 is not as remarkable as other miracle episodes, such as that experienced by Botswana and Hong Kong, especially considering

Figure 7 Relative Output per Worker Over Time



that China started its episode of growth by being only half as productive as Botswana and 20 percent as productive as Hong Kong.

It is worth emphasizing that our definition of miracle episodes (of at least 15 years) rules out those episodes that started after 1982. For instance, Chile, Ireland, and India had miracle experiences that started after 1982 and have continued at least until 1996. In Chile, relative output per worker grew at an average of 3.2 percent starting in 1990 (from 32 percent to 40 percent in 1996). In Ireland, relative output per worker grew at 3 percent starting in 1989 (from 63 percent to 81 percent in 1996), and in India, at 2.3 percent starting in 1992 (from 8 percent to 9 percent in 1996).

Table 7 reports the disaster experiences in our sample period. Note that all countries in this table are located either in Africa or in Latin America. A remarkable feature of these disaster experiences is the associated large and sustained declines in relative output per worker, with some countries seeing their relative output per worker fall by factors of 4 or more. While most countries in this table were relatively unproductive at the onset of these experiences, the Latin American countries were relatively productive. The most notable case is Venezuela, where relative productivity fell from 87 percent in 1969 to 40

Table 7 Disaster Episodes

Country	Annualized Growth (%)	Start Year	Number of Years	Rel. Y/L Start	Rel. Y/L End
Dem. Rep. of Congo	−6.45	1971	25	0.06	0.01
Mauritania	−6.14	1977	19	0.14	0.04
Nicaragua	−5.51	1974	22	0.33	0.10
Mali	−5.06	1980	16	0.06	0.03
Mozambique	−5.03	1971	16	0.08	0.03
Angola	−4.82	1969	27	0.17	0.05
Peru	−4.48	1977	19	0.39	0.16
Nigeria	−3.99	1980	16	0.06	0.03
Central African Rep.	−3.94	1973	23	0.09	0.04
Bolivia	−3.93	1980	16	0.21	0.11
Zambia	−3.74	1976	20	0.09	0.04
Venezuela	−3.69	1968	21	0.87	0.40
Niger	−3.23	1960	36	0.10	0.03
Ghana	−3.09	1978	15	0.08	0.05
Côte d'Ivoire	−3.06	1980	16	0.14	0.08
Chad	−2.91	1980	16	0.07	0.05
Madagascar	−2.72	1975	21	0.06	0.03

See notes in Table 6.

percent in 1989 (see Figure 7, Panel B). As in the case of miracles, a number of disaster experiences started later than 1982 and therefore are not reported in this table. However, we note that countries in this group include Cameroon, Rwanda, Kenya, Honduras, Madagascar, Trinidad and Tobago, Senegal, and South Africa.

4. DEPRESSIONS

In this section, we report depressions in our data set following the characterization of Kehoe and Prescott (2002). A depression is defined as a negative deviation from trend in output per worker that is fast (leading to a fall in output per worker relative to trend of at least 15 percent within ten years) and large (leading to a fall in output per worker relative to trend of at least 20 percent during the depression period). For this section, we also follow Kehoe and Prescott (2002) in defining trend as the average annual growth rate of labor productivity of the United States in the post-war period—about 2 percent. We emphasize that to characterize depressions, we use the raw time series of output per worker for each country relative to a trend growth of 2 percent. This procedure differs from our characterization of miracle and disaster episodes in the previous section, where we use trended data for each country relative to that for the United States. Hence, depressions can be short- or medium-run

Table 8 Depressions—Europe and Latin America

Country	Year at (%) 100	85	80	Lowest Level (%)	Year
Denmark	1972	1980	1990	75	1992
the Netherlands	1976	1983	1992	75	1994
Switzerland	1972	1978	1983	61	1996
Argentina	1979	1982	1985	59	1990
Chile	1970	1975	1975	67	1983
Colombia	1989	1992	1992	71	1993
Costa Rica	1977	1981	1982	57	1996
Dominican Rep.	1980	1990	1990	77	1991
Ecuador	1979	1986	1987	66	1996
El Salvador	1977	1980	1980	58	1989
Guatemala	1979	1984	1986	70	1996
Jamaica	1970	1976	1976	48	1996
Mexico	1980	1986	1987	65	1995
Panama	1981	1987	1988	70	1989
Paraguay	1990	1994	1994	72	1994
Uruguay	1979	1983	1983	73	1985

Notes: Depressions are characterized using raw output per worker relative to a 2 percent trend. The second to fourth columns report the approximate year the depression started, the year in which output per worker relative to trend falls below 85 percent, and the year in which output per worker relative to trend falls below 80 percent. The last two columns report the level and year of the lowest output per worker relative to trend during the depression episode.

episodes (closer to business cycles), while miracles and disasters are long-run characterizations that abstract from business-cycle movements.

We find that depressions are quite common, both among rich and poor countries. Even in our relatively small sample period, we find 53 depression episodes. In Tables 8 and 9, we report 29 depressions in our panel data. We exclude from these tables 24 depression episodes of countries that also faced disaster episodes, as discussed in the previous section. We report the country name and the approximate years in which the depression began, in which output per worker fell below 85 percent (relative to its level in the starting year), and in which output per worker fell below 80 percent (second to forth columns). We also report the lowest level of output per worker relative to trend and year during the depression period in the last two columns.

Table 8 summarizes the depression episodes of countries located in Europe and Latin America during our sample period. Depressions in Denmark, the Netherlands, and Switzerland started in the 1970s, and during these experiences, output per worker relative to trend fell by as much as 25 percent in Denmark and the Netherlands and 39 percent in Switzerland. Many Latin

Table 9 Depressions—Rest of the World

Country	Year at (%) 100	85	80	Lowest Level (%)	Year
New Zealand	1973	1977	1979	59	1992
Benin	1964	1974	1975	74	1980
Congo	1984	1989	1989	57	1996
Ethiopia	1982	1985	1991	60	1992
Gabon	1977	1981	1982	62	1988
Gambia	1982	1990	1992	64	1996
Guinea	1960	1967	1968	64	1984
Iran	1975	1980	1980	55	1989
Jordan	1985	1989	1989	65	1991
Namibia	1978	1980	1980	52	1996
Papua New Guinea	1972	1980	1981	65	1990
Philippines	1980	1984	1985	62	1994
Togo	1980	1986	1987	50	1996

See notes in Table 8.

American economies experienced depressions in the 1970s and early 1980s and saw declines of output per worker relative to trend of up to 50 percent.[16]

Table 9 summarizes the remaining depression experiences in our panel data. With the exception of New Zealand, these are relatively poor economies. However, the depression in New Zealand looks remarkably similar to the other episodes reported in this table. In particular, New Zealand has experienced a long depression, starting around 1973, with a fall in output per worker relative to trend as large as 41 percent in 1992.

5. DISCUSSION

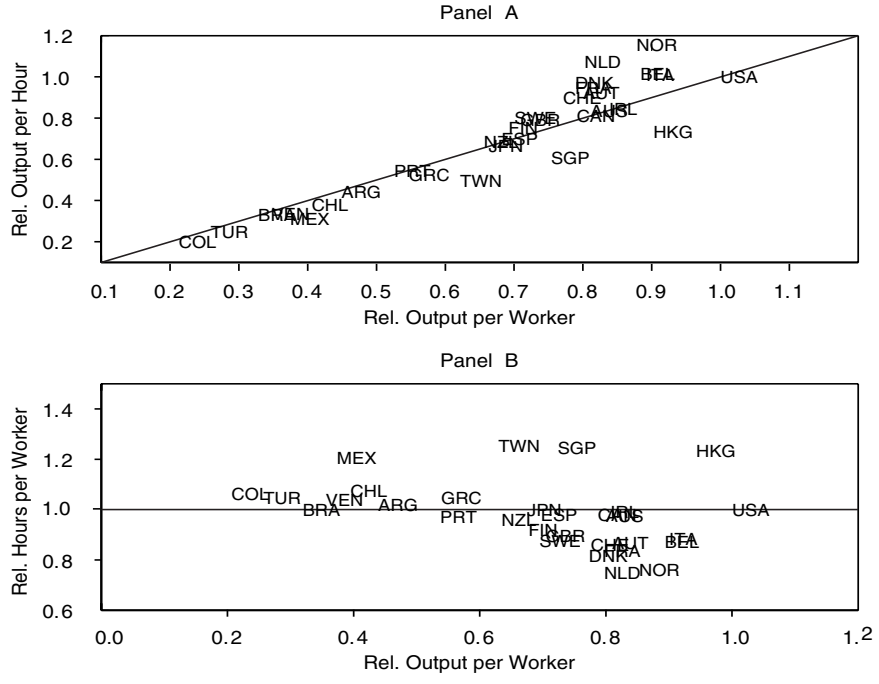
In this section, we discuss our findings relative to (*i*) a measure of labor productivity that includes hours per worker, (*ii*) a restricted set of countries for which price data is collected to compute PPP-conversion factors (Benchmark countries in PWT6.1), and (*iii*) a commonly used measure of income across countries—output per capita.

Hours per Worker

We focused on output per worker as our measure of labor productivity across countries. We chose this measure because of the lack of systematic data on hours per worker for a large set of countries and time periods. However, there

[16] Bergoeing et al. (2002) study the depression episodes of Mexico and Chile in the 1980s.

Figure 8 Output per Worker, Output per Hour, and Hours per Worker (1996)



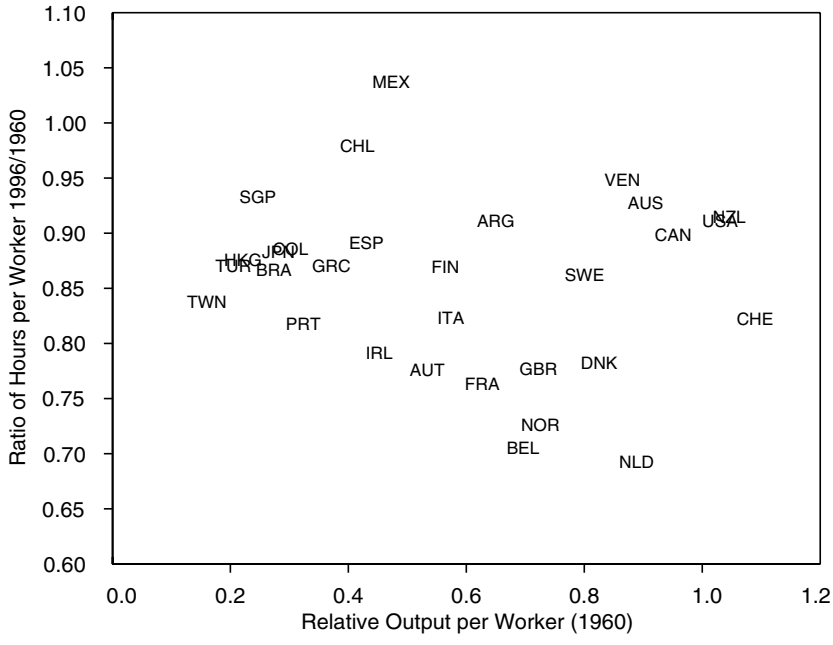
Notes: Output per worker from PWT6.1 is divided by (average) annual hours per worker from GGDC (see Appendix). For this comparison, the data are not trended.

are data on hours per worker for some countries and some time periods. We discuss the available evidence on hours per worker and how this evidence may affect our findings about dispersion and mobility in labor productivity. We combine the PWT6.1 data with the available data on hours per worker from the Conference Board and Groningen Growth and Development Centre (2006) to obtain output per hour.[17] We report the two measures of relative labor productivity for 1996 in Figure 8, Panel A.

In Figure 8, Panel A, countries on the 45-degree line represent those in which hours per worker do not differ from the hours in the United States. This is the case for most countries with some notable but perhaps well-known exceptions. First, European countries tend to have lower hours per worker than

[17] See the Appendix for a description of the data on hours per worker.

Figure 9 Changes in Hours per Worker



does the United States. In particular, output per worker tends to understate labor productivity for these countries by roughly 10 percent.[18] Second, there are countries where hours per worker are higher than in the United States, such as Hong Kong, Singapore, Taiwan, Mexico, and Chile.

To illustrate the importance of differences in hours per worker more directly, we decompose output per hour as the product of output per worker and the inverse of hours per worker. In Figure 8, Panel B, we plot hours per worker relative to that of the United States across countries in 1996. Although differences in hours per worker across countries are not too large, these differences are systematically related to income, with poorer countries observing higher hours per worker than richer countries. Hence, dispersion in output per worker actually understates dispersion in labor productivity (output per hour).

In Figure 9 we plot the ratio of hours per worker, 1996/1960, against the level of hours per worker in 1960. This figure suggests that changes in hours per worker during the 1960–1996 period are not related to the level of development. Hence, our summary statistics of changes in dispersion in labor

[18] For instance, Prescott (2004) and Rogerson (2005) study the implication of tax differences for labor supply levels in Europe and the United States.

productivity over time are not affected by the exclusion of hours per worker. It is worth emphasizing, though, that for some countries in the upper end of the income distribution, changes in hours per worker are substantial. Therefore, growth in output per worker may understate growth in labor productivity for these countries (see some European countries, such as the Netherlands, Belgium, and Norway, in Figure 9).

Benchmark Countries

The PWT6.1 uses detailed price data across countries to construct and price a common international basket of goods. These international prices are then used to convert aggregate measures of output in domestic prices to aggregate measures of output in international prices that are comparable across countries. The factors of conversion are typically called purchasing power parity (PPP). However, actual goods and services prices are collected for a subset of countries (from the ICP studies), called Benchmark countries. Data for the remaining countries are filled in using a variety of statistical techniques, perhaps rendering PPP-converted data for these countries less reliable.

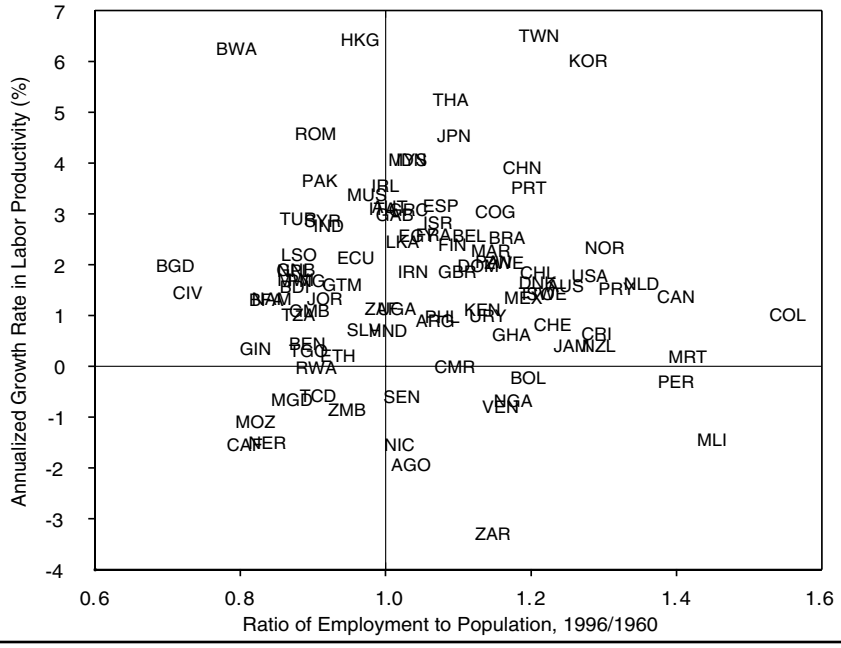
The most comprehensive and recent price collection was in 1996. We restrict our sample to Benchmark countries in 1996 in order to assess the importance of countries with lower quality data for our main findings on labor productivity. Out of 99 countries in our sample, 67 are Benchmark countries in 1996.[19] We restrict our panel data to only these 67 countries and recompute our baseline statistics. Our findings hold for the restricted sample. In particular, we find that there is a large disparity in relative productivity across countries at any point in time in our sample, that disparity has increased since the mid-1980s, and that there have been substantial movements of individual countries in the distribution of relative output per worker.

Output per Capita

We have focused our analysis on output per worker as opposed to output per capita. Our motivation is that facts on output per worker relate more directly to theories of labor productivity. Nevertheless, we recognize that measures of output per capita are more widely available. For instance, Maddison (2001) documents long time series of comparable measures of output per capita for 124 countries, while he offers only limited time series (at most 6 years) of

[19] See the Appendix for the list of these countries.

Figure 10 Changes in Productivity and Employment to Population



output per worker for only 45 countries. Hence, it is of interest to document how different our characterization of labor productivity across countries would be if instead we use data on output per capita. Noticing that output per capita can be decomposed as the product of output per worker and the employment-to-population ratio, we can establish two main findings about the relationship between output per worker and output per capita. First, while there are substantial differences in the employment-to-population ratio across countries, these differences are not systematically related to development. Therefore, our summary statistics characterizing output per worker over time are roughly similar to statistics on output per capita. Second, there are substantial changes in employment-to-population ratios for individual countries over time, and these changes are not systematically related to development or growth in relative productivity (see Figure 10). Therefore, changes in output per capita can severely overstate or understate changes in labor productivity for individual countries.

6. CONCLUSIONS

We have documented three remarkable facts about the distribution of labor productivity across countries: there is a large disparity in labor productivity

across countries in the world, this disparity has increased substantially since the mid-1980s, and there is substantial mobility of individual countries in the distribution of labor productivity over time.

Substantial progress has been made by confronting theories of development to facts. By extending and updating the development facts, we attempt to provide new opportunities and challenges to theories of development. In documenting a number of individual growth experiences, we intend to direct research efforts to explore a number of relevant questions in development. Why have China and India been able to start a miracle episode of growth in the 1980s and 1990s but not other countries such as those in Latin America? What accounts for China's and India's recent growth miracle? Why is labor productivity in Africa falling behind that of the United States since the 1980s if it was catching up until then? Why is labor productivity in Latin America stagnant or falling behind that of the United States? Why is labor productivity in Europe slowing down to levels below that of the United States? Why has dispersion in relative labor productivity increased so much since the mid-1980s? Is there a common factor explaining this fact or is it related to a variety of country-specific factors?

APPENDIX: DATA SOURCES AND DEFINITIONS

We use data from Penn World Tables V6.1 (see Heston, Summers, and Aten 2002) to construct annual time series of PPP-adjusted GDP per worker in chained 1996 prices (variable RGDPWOK). We focus on countries that have data for every year from 1960 to 1996 and that have at least one million in population in 1996. These restrictions render a set of 99 countries, which includes (with country code in parentheses): Angola (AGO), Argentina (ARG), Australia (AUS), Austria (AUT), Burundi (BDI), Belgium (BEL), Benin (BEN), Burkina Faso (BFA), Bangladesh (BGD), Bolivia (BOL), Brazil (BRA), Botswana (BWA), Central African Republic (CAF), Canada (CAN), Switzerland (CHE), Chile (CHL), China (CHN), Côte d'Ivoire (CIV), Cameroon (CMR), Republic of Congo (COG), Colombia (COL), Costa Rica (CRI), Denmark (DNK), Dominican Republic (DOM), Ecuador (ECU), Egypt (EGY), Spain (ESP), Ethiopia (ETH), Finland (FIN), France (FRA), Gabon (GAB), United Kingdom (GBR), Ghana (GHA), Guinea (GIN), Gambia (GMB), Guinea-Bissau (GNB), Greece (GRC), Guatemala (GTM), Hong Kong (HKG), Honduras (HND), Indonesia (IDN), India (IND), Ireland (IRL), Iran (IRN), Israel (ISR), Italy (ITA), Jamaica (JAM), Jordan (JOR), Japan (JPN), Kenya (KEN), Korea (KOR), Sri Lanka (LKA), Lesotho (LSO), Morocco (MAR), Madagascar (MGD), Mexico (MEX), Mali (MLI), Mozam-

bique (MOZ), Mauritania (MRT), Mauritius (MUS), Malawi (MWI), Malaysia (MYS), Namibia (NAM), Niger (NER), Nigeria (NGA), Nicaragua (NIC), the Netherlands (NLD), Norway (NOR), Nepal (NPL), New Zealand (NZL), Pakistan (PAK), Panama (PAN), Peru (PER), Philippines (PHL), Papua New Guinea (PNG), Portugal (PRT), Paraguay (PRY), Romania (ROM), Rwanda (RWA), Senegal (SEN), Singapore (SGP), El Salvador (SLV), Sweden (SWE), Syria (SYR), Chad (TCD), Togo (TGO), Thailand (THA), Trinidad & Tobago (TTO), Turkey (TUR), Taiwan (TWN), Tanzania (TZA), Uganda (UGA), Uruguay (URY), United States (USA), Venezuela (VEN), South Africa (ZAF), Democratic Republic of Congo (ZAR), Zambia (ZMB), and Zimbabwe (ZWE).

In Section 5 we use data on hours worked obtained from the Total Economy Database of the Conference Board and Groningen Growth and Development Centre (2006). We use data on annual hours worked per employee from 1960 to 1996 for the following 30 countries: Argentina, Australia, Austria, Belgium, Brazil, Canada, Switzerland, Chile, Colombia, Denmark, Spain, Finland, France, United Kingdom, Greece, Hong Kong, Ireland, Italy, Japan, Mexico, the Netherlands, Norway, New Zealand, Portugal, Singapore, Sweden, Turkey, Taiwan, United States, and Venezuela. We divide our measure of output per worker from PWT by hours to obtain a measure of output per hour. We make the implicit assumption that employees and self-employed people work the same number of hours. Clearly self employment differs across sectors and therefore countries; whether this assumption is valid or not is an open question. There is some evidence from household surveys in the United States that employees and self-employed people work roughly the same amount of hours.

The Benchmark 1996 countries in our data set are: Argentina, Australia, Austria, Belgium, Benin, Bangladesh, Bolivia, Brazil, Botswana, Canada, Switzerland, Chile, Cote d'Ivoire, Cameroon, Republic of Congo, Denmark, Ecuador, Egypt, Spain, Finland, France, Gabon, United Kingdom, Guinea, Greece, Hong Kong, Indonesia, Ireland, Iran, Israel, Italy, Jamaica, Jordan, Japan, Kenya, Korea, Sri Lanka, Morocco, Madagascar, Mexico, Mali, Mauritius, Malawi, Nigeria, the Netherlands, Norway, Nepal, New Zealand, Pakistan, Panama, Peru, Philippines, Portugal, Romania, Senegal, Singapore, Sweden, Syria, Thailand, Trinidad & Tobago, Turkey, Tanzania, Uruguay, United States, Venezuela, Zambia, and Zimbabwe.

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