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At the Threshold: The Increasing Relevance of the Middle-Income Trap

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At the Threshold: The Increasing Relevance of the Middle-Income Trap

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ABSTRACT: We investigate the existence of a middle-income trap using finite state Markov chains, constant growth thresholds, and mean passage times. As well as studying output per head, we examine the dynamics of its proximate determinants: TFP, the capital-output ratio, and human capital. We find upwards mobility for the capital-output ratio and human capital, but not for relative TFP. The lack of upwards mobility in relative TFP, at least from an intermediate level, suggests that escaping the middle-income category can take many years, and such traps may become increasingly apparent in the years to come.

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WORKING PAPERS

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Contents

I. Introduction

Over the last sixty years, the ranks of high-income countries have expanded more slowly than might once have been expected. Many countries in Latin America and the Middle East have spent several decades at an intermediate level of development. But since Gill and Kharas (2007) introduced the idea of a middle-income trap, wide-ranging discussions of its policy relevance have far outweighed formal statistical evidence. Their working paper and report have been cited more than 1400 times in total.[1] In their original formulation, middle-income countries find themselves caught between the rapidly-changing advanced technology of rich countries, and competition in mature products from poor countries with low wages (Gill and Kharas 2007, p. 5).

In the policy literature, the existence of a trap has often been investigated using informal methods based on charts, with plenty of room for disagreement over each approach and its interpretation. Meanwhile, many discussions take the existence of a trap as more or less given and explore what this implies for growth strategies. For Wade (2016), drawing on informal evidence, the trap seemed 'real enough' to form one basis for reconsidering industrial policy. Ideally, we would have a more rigorous assessment of its extent and origins, and that is what we seek to provide in this paper.

In neoclassical growth models, the growth rate will typically decline for a country converging to a balanced growth path from below, unless the steady-state determinants are themselves moving in a positive direction. But the slowdown would often be modest, and the intimations that not all is well in the 'middle world' seem to go well beyond this conditional convergence effect. The finding of 'premature deindustrialization', due to Rodrik (2016), diagnoses a tendency for manufacturing in late convergence to peak at lower levels of activity, and earlier in the development process, than formerly. Slower growth appears to be one force in emerging discontent, as seen in Eastern Europe (Dijkstra et al. 2020).

But is there a genuine trap? As in much of the literature, we do not treat a trap as literal in the sense that a given income category can never be escaped. We also want to avoid the idea that a trap either exists or does not. Rather, as explicitly argued in Cherif and Hasanov (2019), the issue is the length of time taken to emerge from the middle-income category. In our view, there is a trap if emerging from middle income is a lengthy and uncertain process which compares unfavorably with some historical precedents. Later, we introduce a more precise approach

[1] Citations as listed by Google Scholar, 7 March 2024.

which quantifies the extent of any such trap, using a continuous measure rather than a binary outcome or the testing of a point null hypothesis.

In some accounts, as a country moves to more advanced technologies, this will increasingly require complementary investments and policies — more advanced education, support for particular industries and skills, better business services — that are hard to implement effectively. This does not preclude continued growth, but the task may be harder than a country's past experience might suggest and make greater demands on state capacity.

The middle-income trap has been used to characterize growth in Latin America and, as in Arezki et al. (2021), the Middle East and North Africa. And given the rising share of world population that lives in middle-income countries, in a global environment rather different from that experienced by their precursors, these questions have become more urgent.

As such discussions multiply, it may be useful to examine the trap more formally. The concept's policy relevance helps to explain its appeal, but so does the possibility that it is 'just sufficiently nebulous that it could not be disproved' (Yusuf, 2017, p. 20). The answer to this problem is to define the concept precisely and examine it in the data. We study the existence and origins of a middle-income trap using finite state Markov chains, drawing on ideas in Quah (1993), Feyrer (2008), and Im and Rosenblatt (2015), and other work that we discuss below. When the transition probability from middle-income to high-income is low compared to other upward transitions, that suggests that achieving a relatively high-income level will be harder than earlier growth suggests. We take this to be the problem for which a 'middle-income trap' is shorthand.

That is far from the whole story, however. There may be a significant risk of downwards mobility at earlier stages. A country may take an especially long time, on average, to escape middle-income status if the transition to a high-income state is sometimes delayed by falling back. As in Im and Rosenblatt (2015), we can study this formally using mean passage times derived from transition matrices: the average time it takes to move between particular states, given that both upwards and downwards mobility can arise.

We complement the use of mean passage times with the systematic use of 'constant growth thresholds' to define the income categories. By choosing the categories appropriately, we can make comparisons of mean passage times more informative about the questions of interest. Although such thresholds have been used in some of the prior work in the literature, we explain why they should be the default choice when the subject is the middle-income trap. We also suggest a simple summary statistic, derived by comparing mean passage times under constant growth thresholds. The proposed statistic is a continuous measure of the extent of a trap, which seems preferable to reducing its existence to a yes/no dichotomy.

We first use these tools to investigate a middle-income trap based on GDP data for sixty-five years, from 1950 to 2015. The long-time span means that, even when using five-year intervals, we can draw on more than 1800 transitions between income categories and obtain precise estimates of transition probabilities. The sample of countries represents more than 93% of the world population in 2018. We then use version 10 of the Penn World Table to look at transitions over forty years, between 1975 and 2015. In either case, mobility within the distribution of output per head is low. There is no long-run tendency for absolute convergence, but there is little evidence that transitions from a middle-income category are uniquely difficult.

When we extend the analysis to the proximate determinants of GDP per head, a fuller story emerges. Relative capital intensity and human capital both show upwards mobility. Indeed, the two have been converging across countries, and this has disguised the lack of convergence in relative TFP. If these patterns continue, the future outcomes for output will be driven mainly by the TFP process.[2] A middle-income trap may become increasingly apparent in the years to come, unless higher human capital helps to close the gaps in relative TFP, or unless — as Patel et al. (2021) argue — the convergence process has changed over the last twenty years.

If income classifications are made sufficiently fine, the persistence of middle income can coexist with the persistence of low income, or even a poverty trap. In a companion paper, Imam and Temple (2024), we use the ideas developed here to examine the persistence of low income. We also ask whether the worldwide increase in educational attainment is changing the dynamics of relative TFP, as an endogenous growth perspective might predict. To some extent, policymakers may need to know about both forms of trap, especially if particular investments — such as those in human capital or state capacity — can help both in escaping low income and in lessening the risk of later stagnation at intermediate levels of income.

In summary, the paper makes four main contributions. We explain why constant growth thresholds should be the default choice for Markov chains applied to this question; we replace a yes/no dichotomy for the existence of a trap with a continuous summary measure of its extent; we study potential traps not only in output dynamics but in the proximate determinants of output per head; and we take advantage of the longer time spans of data now available. Several steps in our analysis mirror those in Feyrer (2008), but his data ended in 1989. Since our samples typically end in 2015, we bring more than twenty-five years of new data to bear on

[2] Note that all we are doing here is extrapolating from the final period of data using estimated transition matrices, given that the long-run equilibrium has not been reached; we assume that transition probabilities remain constant over time.

these questions.[3] The longer span of the data means that we can estimate transition probabilities more precisely. It also means we can look at how income dynamics differ between subgroups of countries and between subperiods.

The paper has the following structure. The next section provides background. Section 3 describes the methods and section 4 the data. Section 5 sets out the main results, while section 6 looks again at the proximate GDP determinants, but now using a common sample of countries. Section 7 explores robustness, before section 8 concludes. An appendix covers some technical issues in more detail than the main text.

II. Background

The literature on the middle-income trap distinguishes between an absolute trap (a region of income above which growth becomes more difficult) and a relative trap (a range of income relative to the frontier that is hard to move beyond).[4] Both seem of potential interest but are likely to require different methods. Our empirical work will address only the relative trap, which has arguably been the one more commonly discussed. For reviews of the literature that discuss both types, see Agénor (2017), Glawe and Wagner (2016), and Im and Rosenblatt (2015), while Gill and Kharas (2015) review the broader debate.

Ideally there would be more guidance from theory, and some argue that middle-income traps have no theoretical foundations. But there are many different models of multiple equilibria in development levels, which could sometimes be adapted to deliver either a relative or an absolute trap. Indeed, there are arguably too many models to choose from relative to the scope for testing them against the data; it might then be a mistake to tether an empirical analysis too closely to a single theoretical model.[5]

Before the concept of a middle-income trap was introduced by Gill and Kharas (2007), Acemoglu et al. (2006) had developed a related model. They studied growth strategies or regimes when firms choose whether to innovate or adopt technologies from the world technology frontier. Countries may become trapped in an investment-based regime rather than one which promotes convergence. In retrospect, this can be seen as anticipating the idea of a middle-income trap, and it is among the models discussed in Agénor (2017).

[3] Compared to Quah (1993), for example, this is a doubling of the size of the data set even before improving the country coverage.

[4] Note that, in line with much of the literature, we use 'income' and 'output' more or less interchangeably; with some loss of precision, 'income' should be taken to correspond to GDP.

[5] As Temple (2010, p. 4442) noted, growth economics has often been regarded as theory-rich and data-poor.

Aghion and Bircan (2017) emphasize the Schumpeterian foundations of middle-income traps. For an economy undergoing structural transformation, the process may require complementary investments and policies. State action may be needed to climb the ladder: to improve the quality of institutions, upgrade skills, and stimulate imitation or even innovation. Ideas along these lines could be used to justify either an absolute or a relative middle-income trap. Doner and Schneider (2016) argue that the origins of a trap should ultimately be sought in political economy rather than economics: what matters is whether there are coalitions that favor institutional development and reform.

For an absolute trap, a natural approach is to look at whether growth slows down once a particular income range has been approached. Work in this vein includes Aiyar et al. (2018), Eichengreen et al. (2014) and Felipe et al. (2017). These studies are best suited to examine when and why middle-income countries start growing less quickly. One drawback of this approach is that medium-run global and regional growth varies over time, as when the debt crises of the 1980s and 1990s saw many countries experience slow growth or even output collapses. Distinguishing between an absolute middle-income trap and other forms of slowdown, such as those associated with conditional convergence from below, may not be straightforward. And what ultimately matters is not just whether growth slows down, but the extent and persistence of the slowdown.

The most popular version of a middle-income trap considers ‘middle income’ to be a relative concept. Then, perhaps the most natural approach is to model transitions between income classes, building on Quah (1993).[6] We adapt Quah’s approach in several ways. When specifying the thresholds for the income categories in the Markov chain, we require that a country growing at a constant rate (relative to the US, say) will take a constant length of time to traverse each of the intermediate states. This allows meaningful comparisons of mean passage times between different pairs of states, which can then be combined into a useful continuous measure of the extent of a trap. Further, we look beyond GDP per head and study the evolving distributions of proximate GDP determinants: relative capital intensity, human capital, and TFP. This allows us to consider not only what has happened to date, but also to make predictions about the possible future incidence of middle-income traps.

Our paper will conclude that capital intensity and human capital are converging, but this has disguised much slower progress in relative TFP. If these patterns continue, the lack of TFP convergence will begin to dominate the outcomes for relative output per head. The findings tally with some earlier contributions to the growth literature, notably Krugman (1994). Drawing on a pre-publication version of the classic study by Young (1995), he argued that growth in the

[6] For an alternative approach to a relative trap using time series tests, see Ye and Robertson (2016).

East Asian miracle economies was primarily due to factor accumulation rather than TFP growth. The likely outcome would be a growth slowdown and the end of the 'miracle age' (Yusuf and Evenett 2002; see also Cherif and Hasanov, 2019). The scope for catch-up through factor accumulation would exhaust itself before rich-country status had been reached.

This perspective is consistent with some other work on proximate GDP determinants, including work that was not directed at the middle-income trap. Feyrer (2008) uses Markov chains to study transitions for proximate growth determinants. Our analysis is influenced by his, but we make some changes for the current setting. The states in his paper are defined relative to the world mean (for example, TFP relative to the world mean) and this makes it harder to draw inferences about the extent of catch-up to a frontier or the persistence of an intermediate level of development. In addition, his dataset ended in 1989, whereas we can now take advantage of another twenty-five years of data.

Another paper which overlaps with some of our findings is that of Schelkle (2014). He does not use transition matrices, but finds that, when countries fall further behind the US, the explanation is typically declining relative efficiency rather than declines in relative factor supplies. This is consistent with our findings but reached via a different route.

Our paper is more distantly related to recent work analyzing aggregate convergence, such as Roy et al. (2016), Kremer et al. (2021) and Patel et al. (2021).[7] Our paper complements theirs by adding information on mobility within cross-country distributions of outcomes, especially the proximate determinants of GDP. Recent experience then sheds new light on the prospects for a continuing middle-income trap. At first sight, our findings on those prospects differ substantially from those of Patel et al. (2021). However, their middle-income category — GDP per capita between 7.85 percent and 33.55 percent of the US level, in PPP terms — is less demanding than ours (Patel et al. 2021, fn. 5). In much of our analysis, the middle-income category extends between 36 percent and 72 percent of the US GDP per head. We discuss this choice later, along with the empirical consequences of alternative choices.

[7] For a wider review of the convergence literature, which sometimes touches on the middle-income trap, see Johnson and Papageorgiou (2020).

III. Methods

The use of Markov chains to study ‘distribution dynamics’ has been one alternative to modelling growth using linear regressions, which have well-known problems.[8] To clarify, we are not making a case that one method is somehow ‘better’ than another, since that will often depend on the context and the research question, among other considerations. Instead, our claim is that middle-income traps are often best examined in terms of differences in mobility between relative income classes, and that we can study this using a finite state Markov chain as in Quah (1993). We are not the first authors to propose this approach to middle-income traps — see Im and Rosenblatt (2015) in particular — but we argue that it can be taken further and helps to resolve some of the problems of the existing literature.

Since the basics of Markov chains are well known, we describe them only briefly, following the exposition in Imam and Temple (2023), which in turn draws extensively on Stachurski (2009)[9]. Consider a series $\{X_n, n \geq 0\}$ in discrete time, with a discrete state space $\mathbb{S}$ with states $1, .., S$. We consider a transition matrix $P = [p_{ij}]$ where $p_{ij} = P\{X_n = j | X_{n-1} = i\}$ for all $i, j \in \mathbb{S}$. The elements of this matrix are non-negative and each row sums to one; the individual elements are probabilities of transitions between states. The maintained assumption in a first-order Markov chain, known as the Markov property, is that the transition probabilities depend only on the current state and not on the earlier history of the process. We will investigate this property as part of our later analysis.

Denote the marginal or unconditional distribution over the states at time t by a row vector ψ_t.[10] Over time the evolution of this marginal distribution can be described by

$$\psi_{t+1} = \psi_t \boldsymbol{P}$$

It can be shown (for example, Stachurski, 2009, theorem 4.3.5) that every Markov chain on a finite state space has at least one stationary distribution, satisfying $\psi^* = \psi^* P$. When ψ^* is unique, this will be the long-run outcome. The individual elements of the row vector ψ^* indicate the proportions of time the process will spend in each state if the process runs for a long time. But depending on the elements of the transition matrix P, the process will converge slowly or quickly to the long-run equilibrium, and the nature of the stationary distribution will be more or less sensitive to the individual transition probabilities.

[8] For extended discussions see, for example, Durlauf et al. (2005) and Temple (2021).

[9] See also the presentation in the classic textbook by Norris (1997).

[10] For a more rigorous treatment, see Stachurski (2009, pp. 74-76).

We use five-year intervals as in Kremer et al. (2001). Their analyses suggested that the Markov property did not hold in annual data, but they found no reason to reject it for five-year intervals. To investigate this, they compared a matrix based on ten-year intervals with the square of a matrix based on five-year intervals. If the Markov property holds for five-year transitions, the two matrices should be similar, and that is what they found. We will make use of a similar comparison for output below, with supportive results.

It is worth noting that, relative to the early studies, we now have a lot more data. Quah's data ended more than thirty-five years ago, in 1985; Feyrer's data ended in 1989; and the data of Kremer et al. (2001) ended in 1996. In our case, even though we use five-year intervals rather than annual data, our results typically draw on around a thousand transitions from which to estimate transition probabilities. This means that even quite rare transitions can be estimated with some precision, if a given state is observed in the data often enough.

To allow straightforward interpretation of the results, we translate GDP per head into discrete categories for income, relative to that of a benchmark country or group of countries. This requires us to choose threshold relative income levels that define the categories[11]. We think a natural stipulation here is to choose the thresholds so that, if a country is growing at a constant relative rate, it should take the same amount of time to traverse the intermediate income categories (not the highest or lowest). If relative GDP per head grows exponentially at a constant rate, it has a constant doubling time — indeed, there will be a fixed time specific to any other given proportionate change. Hence, we can meet our stipulation if (and only if) the income thresholds for the categories increase geometrically. We call these *constant growth thresholds* and use them in all the analyses that we present.

To avoid confusion, we are not making any assumption about whether countries grow at constant rates in practice (they clearly do not). Rather, we want to define the spans of our income classes so that the times taken to traverse them can be compared across relative income levels. Otherwise, the comparisons of upwards mobility between different points in the distribution would be undermined: some classes would be harder to traverse than others because of their wider span, and not because they were intrinsically harder to escape.

This choice helps to bring approaches based on transition matrices closer to those examining within-country growth slowdowns. With constant growth thresholds, if a

[11] Note that, because we work in terms of *relative* income, the thresholds are constant; but these correspond to absolute levels of income that change over time, depending on the choice of benchmark countries.

country’s relative growth slows down, the country will take longer to move upwards through the higher income categories. If other middle-income countries behave similarly, at least on average, then slowing relative growth will be reflected in probabilities for upward transitions that are lower for middle-income countries than for countries that are poorer.

Writing well before the concept of a middle-income trap was introduced, Quah (1993) used five states and chose thresholds (0.25, 0.5, 1, 2) where the numbers measure income relative to the world mean. These are an example of constant growth thresholds if growth is measured relative to the growth of the world mean. Kremer et al. (2001) initially used the same thresholds, but then adopted (1/16, 1/8, 1/4, 1/2) where the numbers now measure income relative to the five richest countries. Jones (1997) had earlier used income relative to that in the US, but with six states and thresholds of (0.05, 0.1, 0.2, 0.4, 0.8); see Jones (2016) for an update of this analysis. Again, these are constant growth thresholds.

Although most of this work preceded research interest in a middle-income trap, the results of Quah (1993) and Kremer et al. (2001) do shed some light on the phenomenon.[12]

In Table 1 of Quah (1993), the 23-year transition probability of moving upwards from the (1, 2) income category (relative to the world mean) is 0.24, compared to 0.26 for the next lowest category. In Table 5 of Kremer et al. (2001), the 5-year transition probability of moving upwards from the (1/4, 1/2) category is 0.083, while the probability of moving up from the next lowest category, (1/8, 1/4), is slightly higher, at 0.113. But these differences are clearly only modest in quantitative terms, unlikely to be statistically significant, and do not provide much support for a middle-income trap.

In any case, an approach based purely on upwards mobility will miss part of the story. The risk of downwards mobility also influences the expected length of specific transitions: some middle-income countries may take a long time to ‘graduate’ because they happen to fall back for a time. This means that we should assess the middle-income trap using mean passage times as well as examining upward transitions. The mean passage times reflect the range of possible routes through the various states, taking into account that some routes are more likely than others.

Given a set of constant growth thresholds and a matrix of mean passage times, we can define a middle-income trap in more precise terms than has been the norm in the

[12] Jones (1997, 2016) presents his findings in a way that makes our present comparisons more difficult.

literature. For there to be a trap, the mean passage time from middle to high income should be long, and greater than the mean passage time from low to middle income. In addition, we wish to avoid reducing the complexity of income dynamics to an over-simple dichotomy over whether a trap exists or not. We propose using the difference in mean passage times between the upwards transition to the highest category and the upwards transition to the next-highest category. We call this statistic ΔMPT and use it to summarize some of the later results.

In more recent work directed at the middle-income trap, papers have used constant growth thresholds only sometimes. Han and Wei (2017) come close, with thresholds (0.16, 0.36, 0.75) in their first analysis. We agree with them that achieving 70-75 percent of the frontier level seems a suitable benchmark for high income and will often use a similar threshold in what follows. Im and Rosenblatt (2015) work with two sets of thresholds, one of which is (0.15, 0.30, 0.45, 0.60). A country growing at a constant relative rate will move upwards through these categories increasingly quickly, which seems problematic; for example, going from 0.15 to 0.30 requires a doubling of relative GDP per head, while going from 0.30 to 0.45 is an increase of only 50 percent. In another part of their analysis, the thresholds are based on Kremer et al. (2001) and do increase geometrically in the way we recommend.

Milanovic (2005, Table 7.3) reports transition matrices for 1960-78 and 1978-2000 with four income categories, but the income thresholds do not increase geometrically. Some other papers on the trap, including Bulman et al. (2017), use just three income categories. In that case, there is only one intermediate state, and the question of constant growth thresholds becomes moot. But for present purposes, three income categories will be too few: it will be hard to distinguish between the existence of a middle-income trap versus the existence of a low-income (or poverty) trap. In practice both forms of trap, just one, or neither, may be empirically relevant. Using at least four- or five-income categories, as in this paper, helps to ensure that the different possibilities are not conflated. Given the use of at least four categories, there is nothing in our approach which rules out the coexistence of a low- income trap and a middle-income trap. In a companion paper, Imam and Temple (2024), we investigate the possible existence of a low-income trap using the tools developed here.

Given the literature that followed Quah (1993), which demonstrated that small changes in transition probabilities can greatly alter long-run predictions, we think it is good practice to report the transition counts (the absolute numbers of transitions). This information is not redundant: the transition probabilities can be derived from the transition counts but not vice versa.

That said, we should dispel some potential misconceptions about transition counts, and low counts in particular. As discussed in Imam and Temple (2023), these are not always a problem. If a state x is observed many times in the data but is followed by state y only a handful of times, this should be reliable evidence that the probability of moving from state x to state y is low, and there is no reason for that probability to be estimated imprecisely. A more serious problem arises when a state is observed only rarely in the data. In that case, the numerator and denominator of a transition probability may both be small numbers, and the results will be sensitive to individual cases. But some results will be robust even then: a state which is observed only rarely will have little effect on the long-run properties of the process, such as the stationary distribution and the asymptotic rate of convergence. These points imply that low transition counts should be interpreted carefully and are not in themselves enough to preclude useful findings.

To understand which transition probabilities can be precisely estimated from our data, we will report asymptotic standard errors based on Anderson and Goodman (1957). They derived the asymptotic variances of estimated transition probabilities p_{ij} for a Markov chain; for a transition from state i to j, they showed that

$$\sqrt{n_i}(\hat{p}_{ij} - p_{ij}) \longrightarrow N(0, p_{ij}(1 - p_{ij}))$$

where n_i is the number of observations of state i prior to the final period. In the growth literature, this result was previously used by Proudman et al. (1998) and also noted in Kremer et al. (2001). In our setting, our primary interest is in whether specific transition probabilities underlying our main findings are well determined; put differently, we are interested in the width of the confidence intervals for a subset of the matrix entries, and the question of whether all or most intervals exclude zero is otherwise largely irrelevant.

Quah (1993) identified an emerging tendency towards ‘twin peaks’ in the stationary distribution of relative GDP per head. For that variable, upwards and downwards mobility is limited, and convergence to a stationary distribution may be rather slow. As Imam and Temple (2023) discuss, slow convergence tends to go together with a sensitivity of the stationary distribution to small changes in transition probabilities. These could arise through alternative state definitions, measurement errors, or changes in the sample of countries.[13]

[13] The problem was noted by Ben-David in his discussion of Proudman et al. (1998) and discussed further in Kremer et al. (2001). Müller et al. (2022, Table 1) briefly present a long-run transition matrix using data for 1960-2017 and confirm that transitions between income quartiles are rarely seen.

Similarly to Kremer et al. (2001), we find that convergence to the stationary distribution of GDP per head is rather slow. But it is typically much faster for the proximate growth determinants that we study, and hence the stationary distributions for those variables should be more robust. In each case, we report an asymptotic measure of convergence speed, following Kremer et al. (2001, p. 290). The measure is defined as:

$$\gamma \equiv -\frac{\log(2)}{\log|\lambda_2|}$$

where λ_2 is the second largest eigenvalue (after 1) of the transition matrix. This gives the number of periods needed to halve the norm of the difference between the current distribution and the stationary distribution. Note that, as an asymptotic rate, this does not take the initial distribution into account, and so actual convergence will sometimes be faster than this. We adjust γ for the fact that our intervals are five years apart.

As always with convergence, definitions matter and there is a risk of conflating different economic ideas.[14] The γ statistic tells us how fast the unconditional distribution is converging (asymptotically) to the stationary distribution. But in the case of output, the stationary distribution which the world is converging towards is quite flat: we hence find against absolute convergence. A similar conclusion is obtained for relative TFP. In the stationary distribution, more than half the world's countries are below the highest category. It is this finding, above all, which prompts our suggestion that a middle-income trap may become more apparent in the years to come.

In other work that followed Quah's contributions, Fiaschi and Lavezzi (2003, 2007) defined states by growth as well as income; Im and Rosenblatt (2015) looked for a middle- income trap; and Feyrer (2008), Johnson (2005) and Barseghyan and DiCecio (2011) showed what could be learnt from combining Quah's ideas with those of development accounting.[15] Perhaps the main drawback of the Markov chain approach is that translating the continuous variable of GDP per head into discrete categories can distort the findings (Bulli 2001). An alternative approach is to use stochastic kernels, as in Quah (1997), Johnson (2005), and Barseghyan and DiCecio (2011). But for the questions of most interest here, the results are much easier to report and interpret if we use discrete income categories. Later sections will report on what happens when we choose different thresholds.

Another issue has been the choice of benchmark. Quah (1993) defined his income classes relative to the world mean. As Pearlman (2003) pointed out, this creates scope for an

[14] For a review and discussion of convergence concepts, see Galor (1996).
[15] For some other extensions and applications, see Quah (1996a, 1996b, 1997), while Durlauf and Quah (1999) discussed the approach and how it relates to the goals of a researcher.

internal inconsistency, since the unconditional distribution over states may tend towards one in which all countries would — impossibly — be above the world mean. Kremer et al. (2001) also discussed this problem. We avoid the issue by measuring outcomes relative to the US, as in Jones (1997, 2016); in the robustness section, we will consider what happens when we instead study outcomes relative to the median of the G7 economies.

IV. The Data

Our samples for the various analyses include most of the world's countries and, in our largest sample, represent more than 7.1 billion people in 2018, or more than 93 percent of that year's total population. The countries missing are mainly the transition economies of Europe and central Asia, including successor states of the USSR such as Azerbaijan and Kazakhstan. The latter states would be especially hard to include in a balanced panel: the lack of reliable subnational data for the USSR rules out a continuous time series for each of the successor states. And arguably this set of countries may be following a distinct process, so that including them would have drawbacks of its own.

We draw on two sources for our data on GDP per head (or more loosely, income per head). The first source is the Maddison Project Database 2020. This allows us to start the analysis in 1950 and consider 1885 transitions, based on 145 countries. The Maddison Project measures are designed to allow comparisons across time and space. The 2020 version uses the 1990 ICP benchmark, but with a number of departures from the original Maddison approach; for more details, see Bolt and van Zanden (2020).

The second source is version 10.01 of the Penn World Table (PWT; Feenstra et al. 2015). As with the Maddison data, the panels we use are balanced. Our typical sample based on PWT data starts in 1975 and ends in 2015. The PWT output measure we use is that known in version 10 as 'rgdpo', which is output-side real GDP at chained PPPs, to compare relative productive capacity across countries and over time.

When analyzing the PWT data, rather than using real GDP per head, we use real GDP per adult of working age (15-64), where the data on the working-age population are taken from the World Development Indicators. This approach was used in Mankiw et al. (1992) and may provide a better measure of productivity for our purposes than using either GDP per head or GDP per worker. Although data on GDP per worker are available, the way to define a 'worker' appropriately is often unclear in developing economies with a large informal sector.

A key choice in the analysis will be the category thresholds. The best-known thresholds are those of the World Bank, but they are defined using comparisons at market exchange rates (smoothed using the Bank's Atlas method) rather than in PPP terms. Given our focus on comparative productivity and living standards, we want to make comparisons in PPP terms, and use thresholds that increase geometrically.[16] We initially work with a particular set of constant growth thresholds, namely (0.09, 0.18, 0.36, 0.72). These define the relative advanced level as one greater than 72% of the US level, while an intermediate level (such as middle-income for a GDP series) will be defined as between 36% and 72%. This explicit and sharp definition of middle-income is an advantage of our approach. In the robustness section, we will consider alternative definitions of the middle-income range.

V. Results

First, we look at transitions within the Maddison data on real GDP per capita, between 1950 and 2015. This will be the largest sample used in the paper: a balanced panel of 145 countries observed at 14 points that are five years apart. This leads to data on a total of $NT = 145\times(14-1) = 1{,}885$ transitions. Before we report the results, we note a qualification to our findings: since output is subject to short-run fluctuations and measurement error, the matrices we present will tend to overstate the extent of mobility within the distribution of *potential* output. It is likely that smoothing out short-run fluctuations would reinforce our conclusion that mobility is limited.

When reporting the transition matrices and mean first passage times, we show key entries in bold. These often relate to the transitions between, first, (0.18, 0.36] and (0.36, 0.72], and second, between (0.36, 0.72] and (0.72, ∞); the numbers here are for data relative to the US. If there is a middle-income trap, we would expect the second of these transition probabilities to be lower than the first. Similarly, and perhaps more importantly, we would expect the second mean first passage time to be higher than the first, indicating that up- wards mobility takes longer to achieve as a country moves upwards through the categories.

The results are shown in Tables 1 and 2. In Table 1, the entry in a row and column indicates the probability of moving from the row state to the column state. The individual transition probabilities are derived by asking what proportion of countries in a given row state at time t are found in a given column state at time $t + 1$. By a standard argument, these are the maximum likelihood estimates, as used in Quah (1993) and Kremer et al. (2001) among others.

[16] Felipe et al. (2017) introduce a way to map between thresholds defined in PPP terms and those based on comparisons at market exchange rates, but their method would not lead to constant growth thresholds.

Table 1: Five-year transitions, Maddison data, 1950-2015

Table 1: Five-year transitions, Maddison data, 1950-2015

Transition matrix	<0.09	<0.18	<0.36	<0.72	<∞
<0.09	0.948	0.048	0.005		
	(0.009)	(0.008)	(0.003)		
<0.18	0.068	0.809	0.123		
	(0.013)	(0.020)	(0.017)		
<0.36		0.068	0.833	**0.098**	
		(0.013)	(0.019)	(0.015)	
<0.72		0.004	0.065	0.805	**0.126**
		(0.004)	(0.016)	(0.025)	(0.021)
< ∞				0.090	0.910
				(0.020)	(0.020)
Convergence	$\gamma = 114.4$				
Last period	0.290	0.159	0.207	0.186	0.159
25 years ψ_{T+25}	0.269	0.150	0.199	0.185	0.196
100 years ψ_{T+100}	0.220	0.131	0.186	0.206	0.257
Stationary ψ^*	0.130	0.100	0.174	0.248	0.348
Transition counts					
<0.09	616	31	3	0	0
<0.18	26	309	47	0	0
<0.36	0	27	330	39	0
<0.72	0	1	16	198	31
<∞	0	0	0	19	192
$NT = 1885$	$N = 145$	$T = 13$			

Transitions are always from the row state to the column state. For more details see the text.

Table 1 and later tables also report the final observed distribution (that is, the one in the final period of data) and the marginal distributions to be expected 25 and 100 years later, based on iterating the transition matrix. The 25-year and 100-year projections will be less sensitive than the stationary distribution to individual transition probabilities; see Kremer et al. (2001) for discussion. But the stationary distribution remains an interesting way to reveal tendencies hidden in the data, at least if interpretation is cautious.

Table 2 shows the mean passage times and the mean first recurrence times. In reading the former, the initial state sets the row, and the destination state the column. The entry in a row and column indicates the number of years that will elapse, on average, in moving from the row state to first reaching the column state. These mean passage times consider all possible routes through the states over time, using calculations that are matrix-based as in Grinstead and Snell (2006); for details of how we compute them, see our appendix.

Table 2: Mean passage times, Maddison GDP per capita

MPT/MFR	<0.09	<0.18	<0.36	<0.72	< ∞
<0.09		121.9	176.9	289.4	393.6
<0.18	613.5		89.2	201.7	305.9
<0.36	912.2	298.7		**112.5**	216.7
<0.72	1068.2	454.8	178.9		**104.2**
< ∞	1123.7	510.3	234.4	55.5	
MFR	38.5	50.1	28.7	20.1	14.4

From row state to column state, mean passage times (MPT) and mean first recurrence (MFR) times in years, rounded to one decimal place. For more details see the text.

We can see that upwards mobility is slow, while there are also some downwards transitions. The combination explains why, although the stationary distribution places the greatest mass on the highest output category (relative GDP per capita more than 72 percent of the US level), countries will spend about two-thirds of their time below this category, so there is not absolute convergence. In addition, the asymptotic rate of convergence is slow. All this suggests there are limits to the speed and extent to which countries are converging. But is there a middle-income trap? At first glance, perhaps yes: the middle-income category, running from 36 percent to 72 percent of relative GDP per capita, is the second most important in the stationary distribution. Looking in more detail at the individual transitions, however, there is little evidence of a distinct middle-income trap, as opposed to limited mobility more generally. This lack of mobility is consistent with the earlier work of Quah (1993) and Kremer et al. (2001), among others.

Next, we look at transitions using data from the Penn World Table, for the shorter time period of 1975 to 2015, and a set of countries that represent 92.7% of 2018 global population. The results are shown in Tables 3 and 4, based on data for 134 countries and 8 transitions per country. The results are quite similar to those from the Maddison data, despite the shorter time span. The stationary distribution is relatively flat, as Feyrer (2008) also found. But there is little evidence for a distinct middle-income trap, only for a more general lack of mobility.

What might explain the lack of long-run convergence? To investigate this, we next examine transitions for the proximate determinants of GDP per head. The first step draws on the literature on development accounting that began with Hall and Jones (1999) and Klenow and Rodriguez-Clare (1997), who in turn built on Mankiw et al. (1992). We start with a Cobb-Douglas production function:

$$Y = AK^{\beta}(hL)^{1-\beta}$$

where A is aggregate *TFP*, K is the capital stock, h is human capital and L is the working- age population. We then rewrite this in terms of output per working-age adult and the capital-output ratio, as:

$$\frac{Y}{L} = A^{\frac{1}{1-\beta}} \left(\frac{K}{Y}\right)^{\frac{\beta}{1-\beta}} h \qquad (1)$$

This reformulation has often been adopted because the capital-output ratio will be constant along a balanced growth path[17]. The capital-output ratio can be seen as indexing an economy's level of capital intensity even when A and (K/L) are both growing, as usually considered likely in the long run.

The output contribution assigned to TFP is amplified when the capital-output ratio is held constant. This perspective is especially appropriate when motivated by neoclassical growth models: whenever TFP rises, capital will rise as well as output until an equilibrium capital-output ratio has been restored. It is this indirect effect of TFP on output which, in conjunction with the direct effect, leads output per head to be a convex function of TFP; see, for example, Hsieh and Klenow (2010, p. 209).

The expression suggests that we consider mobility within the distributions of relative K/Y, human capital h, and one or more measures of A, as in Feyrer (2008). Feyrer was primarily interested in whether the stationary distributions were single-peaked, or twin-peaked in ways that could explain a bimodal stationary distribution for output per head. Here, we are especially interested in the extent of upwards mobility in the proximate determinants of GDP per head, and the stationary distributions associated with their dynamics.

[17] In growth accounting, this form of decomposition may have originated with David (1977).

Table 3: Five-year transitions, PWT, 1975-2015

Transition matrix	<0.09	<0.18	<0.36	<0.72	$<\infty$
<0.09	0.909	0.086	0.006		
	(0.015)	(0.015)	(0.004)		
<0.18	0.167	0.685	0.148		
	(0.026)	(0.033)	(0.025)		
<0.36	0.005	0.115	0.770	**0.110**	
	(0.005)	(0.023)	(0.030)	(0.022)	
<0.72		0.011	0.087	0.777	**0.125**
		(0.008)	(0.021)	(0.031)	(0.024)
$<\infty$			0.007	0.104	0.889
			(0.007)	(0.026)	(0.027)
Convergence	$\gamma = 82.6$				
Last period	0.276	0.172	0.209	0.164	0.179
25 years ψ_{T+25}	0.289	0.158	0.190	0.177	0.186
100 years ψ_{T+100}	0.290	0.151	0.179	0.181	0.199
Stationary ψ^*	0.280	0.148	0.179	0.185	0.208
Transition counts					
<0.09	318	30	2	0	0
<0.18	34	139	30	0	0
<0.36	1	23	154	22	0
<0.72	0	2	16	143	23
$<\infty$	0	0	1	14	120
$NT = 1072$	$N = 134$	$T = 8$			

For more details see the text.

When we choose thresholds for the proximate determinants, it is important to note that they will typically be less dispersed than output per head (Table 3 and 4). This is because the outcome for output per head can be affected by shortfalls in all the determinants, which then compound into very low relative output. With this in mind, in this section we work with a new set of constant growth thresholds. We retain 0.72 as the benchmark for an advanced economy, and define the thresholds as (0.32, 0.48, 0.72) which increase geometrically by the factor 3/2. An alternative approach would be to use the quartiles in the first period. This would be likely to mean each state is well represented, but it would not lead to constant growth thresholds.

Table 4: Mean passage times, PWT

MPT/MFR	<0.09	<0.18	<0.36	<0.72	$< \infty$
<0.09	0.0	62.5	138.6	283.9	445.4
<0.18	133.0	0.0	89.5	234.8	396.3
<0.36	249.9	124.3	0.0	**145.3**	306.8
<0.72	338.0	211.7	109.2	0.0	**161.5**
$< \infty$	377.1	250.9	147.0	54.7	0.0
MFR	17.8	33.8	28.0	27.0	24.0

Times in years, rounded to one decimal place. For more details see the text.

We start with the capital-output ratio, in Tables 5 and 6. We use data on the ratio relative to the US, computed from the Penn World Table using current-price series ‘cn’ and ‘cgdpo’, between 1975 and 2015. There is substantial upwards mobility in this proximate growth determinant, but only limited downwards mobility.

There is some weak evidence for an intermediate trap, in that the transition into the highest category has lower probability than the upward transition into the next-highest category; but the difference is not large, as reflected in the mean passage times in Table 6.

Given these patterns, it is not surprising that the asymptotic rate of convergence is fast, and it can be seen that the distribution in the last period (2010-2015) is already close to the stationary distribution. If there is to be a middle-income trap, now or in the future, the explanation is unlikely to be found in equilibrium differences in capital intensity. This is consistent with the finding of Caselli and Feyrer (2007) that the marginal product of capital is similar across countries, but our results consider a larger set of countries, especially low-income countries not well represented in the Caselli and Feyrer dataset.

Table 5: Five-year transitions, K/Y, 1975-2015

Transition matrix	<0.32	<0.48	<0.72	<∞
<0.32	0.660	0.241	0.093	0.006
	(0.037)	(0.034)	(0.023)	(0.006)
<0.48	0.047	0.524	**0.340**	0.089
	(0.015)	(0.036)	(0.034)	(0.021)
<0.72	0.004	0.101	0.552	**0.343**
	(0.004)	(0.018)	(0.030)	(0.029)
<∞		0.005	0.049	0.946
		(0.003)	(0.009)	(0.009)
Convergence	$\gamma = 12.6$			
Last period	0.000	0.058	0.129	0.813
25 years ψ_{T+25}	0.006	0.039	0.124	0.831
100 years ψ_{T+100}	0.007	0.038	0.122	0.834
Stationary ψ^*	0.007	0.038	0.122	0.834
Transition counts				
<0.32	107	39	15	1
<0.48 2	9	100	65	17
<0.72	1	28	153	95
<∞	0	3	30	577
$NT = 1240$ $N = 155$ $T = 8$				

For more details see the text.

Table 6: Mean passage times, K/Y

MPT/MFR	<0.32	<0.48	<0.72	< ∞
<0.32	0.0	95.3	39.3	38.5
<0.48	2177.9	0.0	**32.2**	26.8
<0.72	2390.1	272.6	0.0	**17.5**
< ∞	2463.2	340.3	95.4	0.0
MFR	765.8	132.6	41.1	6.0

Times in years, rounded to one decimal place. For more details see the text.

Next, we look at transitions for human capital. The variable of interest is human capital relative to the US, computed from version 10.01 of the Penn World Table. It is the exponential of a piecewise linear function of years of schooling, using the approach which became common in the wake of Hall and Jones (1999) and Caselli (2005), and which appeals to the large empirical literature on Mincerian wage regressions[18]. If *s* is the average years of schooling, the human capital index is equal to exp(ϕ(s)) where ϕ(s) is piecewise linear:.

$$\begin{aligned}\phi(s) &= 0.134 \cdot s && \text{if } s \leq 4\\ &= 0.134 \cdot 4 + 0.101(s-4) && \text{if } 4 < s \leq 8\\ &= 0.134 \cdot 4 + 0.101 \cdot 4 + 0.068(s-8) && \text{if } s > 8\end{aligned}$$

We present results in Tables 7 and 8, for 1975-2015. A clear pattern is discernible: there is very little downwards mobility in relative human capital, but some upwards mobility, albeit slow for the transition to the highest category. Given these patterns of mobility, it is not surprising that the stationary distribution has most of its mass in the highest category, nor that the process still has further to run: compare the 'last period' and 'stationary' rows in Table 7. Even after another 25 years, about 40% of countries will be outside the highest category of relative human capital, but eventually absolute convergence will be achieved.

Table 7: Five-year transitions, human capital, 1975-2015

Transition matrix	<0.32	<0.48	<0.72	<∞
<0.32	0.774	0.226		
	(0.075)	(0.075)		
<0.48	0.007	0.856	0.137	
	(0.005)	(0.020)	(0.020)	
<0.72		0.010	0.893	0.097
		(0.005)	(0.015)	(0.015)
<∞			0.014	0.986
			(0.007)	(0.007)
Convergence	$\gamma = 36.2$			

[18] Bils and Klenow (2000) used the connection with these regressions to motivate an aggregate human capital measure based on an exponential in years of schooling.

Last period	0.000	0.186	0.357	0.457
25 years ψ_{T+25}	0.003	0.100	0.309	0.588
100 years ψ_{T+100}	0.001	0.026	0.179	0.794
Stationary ψ^*	0.000	0.009	0.122	0.869
Transition counts				
<0.32	24	7	0	0
<0.48	2	262	42	0
<0.72	0	4	358	39
<∞	0	0	4	290
$NT = 1032$ $N = 129$ $T = 8$				

For more details see the text.

Table 8: Mean passage times, human capital

MPT/MFR	< 0.32	< 0.48	< 0.72	$< \infty$
<0.32	0.0	22.1	59.6	114.9
<0.48	86536.9	0.0	37.5	92.7
<0.72	90621.2	4084.4	0.0	55.3
< ∞	90988.7	4451.9	367.5	0.0
MFR	19545.6	565.7	41.1	5.8

Times in years, rounded to one decimal place. For more details see the text.

Next, we look at the patterns in relative TFP, again for 1975-2015. This first analysis uses the TFP measure ‘ctfp’ from version 10.01 of the Penn World Table, which is computed from a measure of real output deflated by a Törnqvist quantity index of factor endowments; for more details see Feenstra et al. (2015, Section V).

The results can be found in Tables 9 and 10. We find upwards mobility, but there is also some downwards mobility, not least from the highest category. This explains why the stationary distribution places significant mass on the second-highest category. The analysis predicts that, even in the very long run, more than half the world’s countries will have TFP less than 72 percent of the US level. This statistic indicates that a lack of absolute convergence in TFP may be one source of a middle-income trap. One drawback is that the sample covers only 90 countries, representing about 78 percent of the 2018 world population. Later in the paper, we will present some evidence for a larger sample that supports the finding.

Table 9: Five-year transitions, TFP from PWT, 1975-2015

Transition matrix	<0.32	<0.48	<0.72	<∞
<0.32	0.750	0.250		
	(0.082)	(0.082)		
<0.48	0.087	0.685	**0.217**	**0.011**
	(0.029)	(0.048)	(0.043)	(0.011)
<0.72	0.011	0.173	0.631	**0.184**
	(0.008)	(0.028)	(0.036)	(0.029)
<∞		0.005	0.126	0.869
		(0.003)	(0.016)	(0.016)
Convergence	γ = 23.8			
Last period	0.033	0.200	0.322	0.444
25 years ψ_{T+25}	0.073	0.211	0.278	0.438
100 years ψ_{T+100}	0.090	0.227	0.274	0.409
Stationary ψ^*	0.092	0.229	0.274	0.405
Transition counts				
<0.32	21	7	0	0
<0.48	8	63	20	1
<0.72	2	31	113	33
<∞	0	2	53	366
NT = 720 N = 90 T = 8				

For more details see the text.

Table 10: Mean passage times, PWT TFP

MPT/MFR	<0.32	<0.48	<0.72	< ∞
<0.32	0.0	20.0	51.4	102.1
<0.48	197.4	0.0	**31.4**	82.1
<0.72	248.9	64.3	0.0	**55.2**
< ∞	285.3	100.2	39.4	0.0
MFR	54.3	21.8	18.3	12.3

Times in years, rounded to one decimal place. For more details see the text.

Taken together, what do these results on proximate GDP determinants imply? We find a lack of absolute convergence in relative TFP, unlike the cases of the relative capital-output ratio and relative human capital. (Indeed, the cross-country distribution for the relative capital-output ratio is already close to the stationary distribution.)

These results suggest that a middle-income trap may become more prominent rather than less. Over the last four decades, relative TFP has been converging to a distribution in which more than half the world's countries remain below the highest category (72 percent of the US level). Thus far, this has been offset or hidden by absolute convergence in capital intensity and human capital, where the highest category is becoming the norm. The combination suggests that a middle-income trap may become more, rather than less, prominent over time. The failure to achieve absolute convergence in relative TFP will leave many countries well short of the frontier.

VI. Common Sample

Thus far, we have used the largest available sample for each series. This helps in obtaining precise estimates of the transition probabilities, but also means that countries move in and out of the sample with the choice of series. This would not be a major problem if countries are missing at random, but in practice the likelihood of omission may vary with economic conditions. Moreover, given our central research questions and (especially) that we examine proximate GDP determinants, it might seem more natural and rigorous to base the analysis on a consistent sample.

In this section, we make two relevant changes to this end. First, we replace the sophisticated TFP measure from version 10.01 of the Penn World Table with a naive or 'basic' one, computed from equation (1) and hence available for a larger number of countries. To construct this measure, we need an assumption about the output-capital elasticity β. Feenstra et al. (2015, p. 3178) report an average labor share of 0.52, implying an output-capital elasticity of $\beta = 0.48$ under perfect competition.[19] This is higher than usually adopted, and we will later consider a lower value for β.

Second, we look at outcomes for output per working-age adult and its proximate determinants, including basic TFP, now based on a common sample of countries that represent 92 percent of the 2018 global population. This approach again indicates that there is a mid-level trap for basic TFP, but since this has been offset by upwards mobility in relative capital intensity and human capital, there has been much less evidence for a middle-income trap in output per working-age adult.

[19] It might be suggested that we should allow the labor share to vary across countries. In the Cobb-Douglas case, however, this would be problematic, because TFP is an index number defined relative to a particular technology. See Temple (2012) for more discussion.

For each series, we work with four states. Before we proceed, since we are looking at both output and its determinants, we should also discuss the extent to which the various stationary distributions can be expected to tally with one another. In particular, given absolute convergence in human capital and the capital-output ratio, one might expect the stationary distribution of relative output per head to mirror the stationary distribution of relative TFP.

This is more complicated than it looks, however, and to see why, we return to equation 1 from earlier in the paper:

$$\frac{Y}{L} = A^{\frac{1}{1-\beta}} \left(\frac{K}{Y}\right)^{\frac{\beta}{1-\beta}} h \qquad (2)$$

As explained previously, conditional on the capital-output ratio, the effect of TFP is amplified, because increases in TFP will induce an increase in capital services. Indeed, output per head will be a convex function of TFP. This means that the stationary distribution of relative output per head will not simply mirror the distribution of relative TFP, even when we apply (as we now do) the same set of thresholds to both.

Rather than present a large number of transition matrices, we summarize the results using stationary distributions and our statistic for gauging a middle-income trap, ΔMPT. As described earlier, this is the absolute difference in mean passage times between the upwards transition to the highest category and the upwards transition to the next highest.

The results are shown in Table 12 and the stationary distributions in Figure 1; the four numbered states on the horizontal axis are ordered from low (1) to high (4) and correspond to the four states in the Markov chains. We can see that relative capital-output ratios and human capital are expected to converge, spending most of the time in the highest state. But the stationary distribution of relative output per working-age adult appears to be mildly twin-peaked, while even in the long run many countries will be some way behind the frontier in relative (basic) TFP.

Figure 1: The stationary distributions

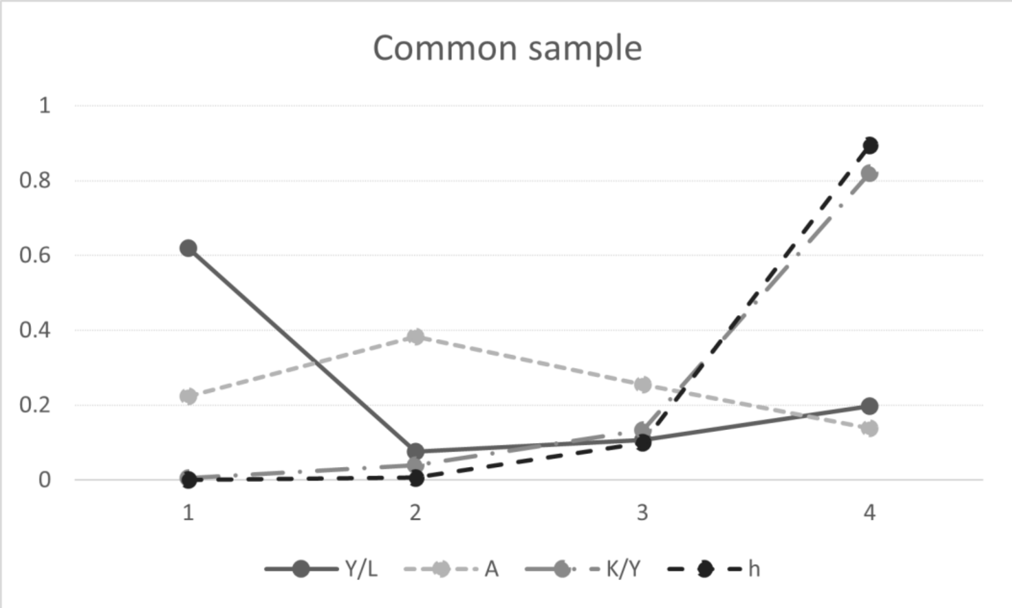

Table 11: Findings, common sample

	<0.32	<0.48	<0.72	$< \infty$	Δ MPT
Output per w/a adult	0.619	0.076	0.107	0.198	-24.8
Basic TFP	0.224	0.383	0.255	0.138	127.2
K/Y ratio	0.006	0.040	0.134	0.820	-11.2
Human capital	0.000	0.006	0.099	0.894	17.2
	$NT = 976$	$N = 122$	$T = 8$		

The table shows stationary distributions for relative output per working-age adult and its proximate determinants. For more details see the text.

Table 12: Findings, common sample, benchmarked to G7

	<0.32	<0.48	<0.72	$< \infty$	Δ MPT
Output per w/a adult	0.638	0.104	0.070	0.188	81.4
Basic TFP	0.078	0.208	0.314	0.401	29.6
K/Y ratio	0.029	0.078	0.216	0.677	1.8
Human capital	0.000	0.004	0.131	0.866	13.3
	$NT = 976$	$N = 122$	$T = 8$		

The table shows stationary distributions for relative output per working-age adult and its proximate determinants, this time benchmarked against the median of the G7 rather than the US. For more details see the text.

These results tally closely with Feyrer (2008), but with more years of data and a greater focus on catching up to the frontier, rather than comparisons with the world mean. The lack of upwards mobility in TFP is glaring: the ΔMPT statistic for this series and sample is 127.2 years. At least on average, moving into the highest relative TFP category may be the work of many decades.

One risk of benchmarking outcomes against the US is that the findings become sensitive to particular developments in the US, such as the New Economy boom of the 1990s (see Temple 2002). So, we now consider the same common-sample exercise, but this time with outcomes benchmarked against the median of the G7 economies, rather than just the US.[20] We prefer this approach to using, say, the richest five economies at each date, because the latter will sometimes include oil producers whose fortunes fluctuate.

Table 12 does show some interesting differences: more evidence of a middle-income trap for output, and somewhat less evidence for basic TFP, as the ΔMPT statistic for the latter has fallen to 29.6 years. But it remains the case that, even in the long run, almost 60 percent of countries will be outside the highest relative TFP category.

Another natural objection to our analysis is that we are using discrete income categories, and so the results could be sensitive to alternative choices of thresholds.[21] In Table 13, we repeat the common sample exercise, but make the highest threshold less demanding (0.64 rather than 0.72) and then adjust the others to be constant growth thresholds. The results are similar, although now the ΔMPT statistic for relative TFP is lower, at 71.7 years.

Table 13: Findings, common sample, new thresholds

	<0.36	<0.48	<0.64	< ∞	Δ MPT
Output per w/a adult	0.639	0.058	0.067	0.236	-9.7
Basic TFP	0.361	0.287	0.170	0.182	71.7
K/Y ratio	0.014	0.034	0.088	0.864	-20.6
Human capital	0.000	0.002	0.031	0.967	3.2
	$NT = 976$	$N = 122$	$T = 8$		

The table shows stationary distributions for relative output per working-age adult and its proximate determinants, based on an alternative set of thresholds. For more details see the text.

We have also generated results (not reported) with a more conventional value for β, of

[20] The G7 countries are Canada, France, Germany, Italy, Japan, the UK, and the USA. Although most of these economies were badly affected by the Second World War, those effects are likely to have dissipated before the start of our sample, in 1975.

[21] For an approach which groups countries without predefined thresholds, see Anderson et al. (2016).

1/3, reflecting a common choice in the literature, albeit one that is probably too low. We continue to find a mid-level trap for relative TFP in that case, and the lack of upwards mobility into the top category is even more pronounced.

What do these findings predict? Over time, a middle-income trap for output per head may become more apparent rather than less, once the convergence of capital intensity and human capital no longer offsets the lack of upwards mobility into advanced levels of relative TFP. But perhaps the higher absolute levels of human capital already achieved will be important to increasing relative TFP in the years to come. In that case, the dynamics of TFP could yet change over time, even without further changes in the economic environment. This hypothesis is explored further as part of a companion paper on the low-income trap, Imam and Temple (2024).

VII. Robustness

In this section, we consider some further dimensions of robustness. One of the maintained assumptions of the analysis is that the various series can be well described by a first-order Markov process, in which transition probabilities depend only on the current state and not on earlier states. Kremer et al. (2001) found that output transitions at five-year intervals can be so described, but not transitions at annual intervals. We have used five-year intervals thus far. To examine the first-order assumption, we adopt a comparison similar to Kremer et al. (2001). Using the Maddison data set, which extends furthest back in time, we compute 10-year transitions and then compare them with the square of a transition matrix for the same time span based on 5-year transitions.

The results are shown in Table 14. The two matrices are remarkably similar, perhaps the main noteworthy difference being in downwards transitions from the highest output category; some of the downwards transitions over 5-year intervals may be temporary, perhaps where countries are close to the boundary. The implied stationary distributions are similar. Probably reflecting the difference in downwards mobility just noted, the 10-year transitions do imply a higher long-run incidence of the highest output category than expected with 5-year transitions. Overall, though, the results are close, and we see them as supporting the use of a first-order process for 5-year intervals applied to the Maddison data. We reach similar conclusions when looking at 10-year transitions in the Penn World Table data (results not reported, but available on request).

Table 14: 5-year and 10-year transitions, Maddison data, 1950-2010

5-year, squared	<0.09	<0.18	<0.36	<0.72	<∞
<0.09	0.906	0.079	0.014		
<0.18	0.118	0.669	0.201	0.012	
<0.36	0.005	0.121	0.705	0.156	0.013
<0.72		0.005	0.110	0.655	0.230
<∞			0.006	0.147	0.847
10-year	<0.09	<0.18	<0.36	<0.72	<∞
<0.09	0.914	0.073	0.013		
<0.18	0.109	0.685	0.201	0.005	
<0.36		0.120	0.727	0.137	0.016
<0.72			0.073	0.745	0.182
<∞			0.011	0.088	0.901
Stationary (5-year) $\psi*$	0.129	0.095	0.167	0.237	0.371
Stationary (10-year) $\psi*$	0.096	0.076	0.141	0.234	0.453
$N = 145$	$T = 6$	(10-year)	$T = 12$	(5-year)	

For more details see the text.

In our next robustness test, we examine whether the results change when we exclude exporters of oil and minerals. Kremer et al. (2001) excluded 20 countries with high shares of the mining and quarrying sector in GDP, based on sectoral data from the United Nations. They argued that these countries may follow different dynamics, not least because oil exporters will be heavily affected by the oil price. We have computed a transition matrix for the Maddison data, excluding the same 20 countries that Kremer et al. (2001) omitted. The stationary distributions with and without these countries are compared in Table 15. Excluding these 20 countries leaves the stationary distribution little changed.

Thus far, we have assumed that each Markov process is homogeneous in time. Since transition probabilities might evolve, we now split the time span in two: we look at 1950-80 and 1980-2015 separately, again for the Maddison data. Examining subperiods involves a trade-off between robustness and efficiency: allowing the probabilities to change increases robustness in one dimension, but means we typically have fewer observations from which to estimate each transition probability. But as can be seen in Table 15, the stationary distributions are fairly similar between the two subperiods.

Table 15: Robustness tests

Oil/mineral producers	<0.09	<0.18	<0.36	<0.72	$< \infty$
With	0.130	0.100	0.174	0.248	0.348
Without	0.129	0.090	0.142	0.265	0.374
Shorter spans					
1950-1980	0.140	0.101	0.205	0.224	0.331
1980-2015	0.182	0.145	0.191	0.230	0.252

Robustness tests: we compare stationary distributions for the Maddison data when excluding the Kremer et al. (2001) oil and mineral producers. We also compare stationary distributions for two subperiods, again using the Maddison data.

Interestingly, there is no tendency for the 1980-2015 time period to indicate greater long-run absolute convergence than for the 1950-80 time period. Given the findings of Patel et al. (2021), it is possible that a subperiod starting in the 1990s or early 2000s would yield stronger evidence of absolute convergence. At least when using the methods of this paper, more years of data would be needed for reliable findings in this respect.

VIII. Conclusion

The idea of a middle-income trap has been much discussed, not without controversy. We recommend that it is studied using transitions between relative income categories, and that it makes sense to examine the dynamics of the determinants of income, as well as income itself. By analyzing these separately, we can come to a better understanding of the prospects for upwards mobility and ultimate convergence in GDP per head.

When we turn to the data, we find that the stationary distribution for output per head implies long-run dispersion across a range of relative income categories, consistent with the usual finding that countries do not show absolute convergence. But comparisons of mean passage times tend to point against the importance of a distinct middle-income trap. Instead, there is a general lack of mobility and a failure to achieve absolute convergence.

The findings extend beyond this, however. We have examined mobility not only within the distribution of relative output per head, but also within its proximate determinants — relative TFP, capital intensity, and human capital. Our results suggest that capital-output ratios and human capital are on course for absolute convergence, which has been hiding a lack of absolute convergence in TFP predicted to extend long into the future. If these patterns continue, the dynamics of relative TFP will come to dominate, and middle-income traps may become increasingly apparent.

One qualification is that we are extrapolating from experience since the mid-1970s, and the convergence process may have changed in the most recent twenty years (Patel et al. 2021). It is also possible that higher absolute levels of human capital might unlock the upwards mobility in relative TFP that has been rare in the data thus far. This question is investigated in Imam and Temple (2024), which uses the tools of this paper to examine the relative performance of low-income countries.

Are there implications for policymakers? One interpretation of a middle-income trap runs as follows: developing countries can reach an intermediate level of development through conventional economic reforms — macroeconomic stability, opening up the economy, and building institutions and human capital — but reaching an advanced level requires further changes, such as complementary investments that may be harder to carry out well than sometimes assumed.

Our own emphasis on the long-run role of TFP dynamics may help to sharpen the focus of policy discussions. Yusuf (2017, p. 27) contended that 'If escape from the MIT requires elaborating current growth theories and augmenting the list of policies specific to middle-income countries, that challenge has still to be met.' In terms of microeconomic implications, the current findings point to the importance of studying firm-level learning and technological upgrading in developing countries: for a review, see Verhoogen (2023). But low TFP may not be a question solely of firm decisions, since one reason for a lack of absolute convergence in aggregate TFP may be variation in the provision and quality of infrastructure.

Naturally in a paper of this kind, there are many other relevant considerations that we have barely touched upon. For example, the ongoing revolution in artificial intelligence may disproportionately benefit advanced economies, while proving harder to apply in middle-income countries (Alonso et al. 2020). The impact of a green transition could also be ambiguous in its effects. These broader considerations, as well as the statistical evidence we have put forward, suggest that policymakers may yet need a better understanding of the middle-income trap in the years to come.

Annex I. Quintiles and mobility

Given the concern that specific threshold choices are inevitably somewhat arbitrary, one alternative to our approach would be the use of income quantiles. At first sight, the quantile-based approach might seem less arbitrary and would ensure that each state is well represented in the data. But in our setting, there is no guarantee that quantiles will line up with reasonable interpretations of 'middle income'. In an analysis where the categories are based on continually updating quantiles, the implicit income thresholds will be varying over time, a country growing at a constant relative rate will traverse the categories at varying speeds - which makes comparisons of mean passage times harder to interpret - and the stationary distribution will be uninformative by construction. These are all good reasons to avoid quantile-based studies of mobility when the subject of interest is the middle-income

Unique stationary distributions

The stationary distribution is hard to interpret unless it is unique. Once a transition matrix has been estimated, uniqueness can be verified using the Dobrushin coefficient, α(p), introduced in Dobrushin (1956). Our presentation follows Stachurski (2009, section 4.3.2) and repeats material in Imam and Temple (2023). Consider a right stochastic matrix M defined over the set of states S, and denote the transition probability from state *x* to state *y* by *p(x, y)*. The Dobrushin coefficient is defined as:

$$\alpha(p) := \min_{(x,x')\in\mathcal{S}\times\mathcal{S}} \sum_{y\in\mathcal{S}} p(x,y) \wedge p(x',y)$$

where the notation $a \wedge b := min\{a, b\}$ and the index $\alpha(p) \in [0,1]$. It can be shown that the process is globally stable if and only if there exists a strictly positive integer t such that $\alpha(p^t) > 0$. If this is true, the process will converge to a unique stationary distribution regardless of the initial conditions.[22]

This means we can take a transition matrix P and check whether it implies a unique stationary distribution. If the Dobrushin coefficient *α(p)* for *P* is non-zero, the process is globally stable. If the coefficient is zero, we should compute the Dobrushin coefficient for an iterate of the transition matrix, P^2, and try again. As long as we can find a strictly positive integer *t* such that the coefficient associated with P^t is non-zero, the process is globally stable. That turns out to be the case for each of the transition matrices we report.

[22] For a formal statement, see Stachurski (2009, theorem 4.3.18); a related result appears in Stokey et al. (1989, theorem 11.4).

Mean passage times

Our approach to calculating the mean passage times follows Grinstead and Snell (2006), pp. 456-460. Let P be the transition matrix of an ergodic chain, and let *W* be the matrix whose rows are all equal to the stationary distribution for P. Then the 'fundamental matrix' is given by $Z \equiv (I - P + W)^{-1}$ where the inverse always exists given the structure of the problem. The mean passage times for an ergodic chain, from state *i* to state *j* where $i \neq j$, are then determined from the individual entries in the fundamental matrix *Z* and the stationary distribution *w* by[23]:

$$m_{ij} = \frac{z_{jj} - z_{ij}}{w_j}$$

[23] For a detailed derivation, see Grinstead and Snell (2006). In this case, the entries on the main diagonal are zeroes; in some presentations, as in Hunter (2018), the entries on the main diagonal are mean first recurrence times.

Countries used

Table 16: 145 countries used in Table 1

1 AFG	AGO	ALB	ARE	ARG	AUS	AUT	BDI	BEL	BEN
2 BFA	BGD	BGR	BHR	BOL	BRA	BRB	BWA	CAF	CAN
3 CHE	CHL	CHN	CIV	CMR	COD	COG	COL	COM	CPV
4 CRI	CSK	CUB	CYP	DEU	DJI	DMA	DNK	DOM	DZA
5 ECU	EGY	ESP	ETH	FIN	FRA	GAB	GBR	GHA	GIN
6 GMB	GNB	GNQ	GRC	GTM	HKG	HND	HTI	HUN	IDN
7 IND	IRL	IRN	IRQ	ISL	ISR	ITA	JAM	JOR	JPN
8 KEN	KHM	KOR	KWT	LAO	LBN	LBR	LBY	LCA	LKA
9 LSO	LUX	MAR	MDG	MEX	MLI	MLT	MMR	MNG	MOZ
10 MRT	MUS	MWI	MYS	NAM	NER	NGA	NIC	NLD	NOR
11 NPL	NZL	OMN	PAK	PAN	PER	PHL	POL	PRI	PRT
12 PRY	PSE	QAT	ROU	RWA	SAU	SDN	SEN	SGP	SLE
13 SLV	STP	SUN	SWE	SWZ	SYC	SYR	TCD	TGO	THA
14 TTO	TUN	TUR	TWN	TZA	UGA	URY	USA	VEN	VNM
15 YEM	YUG	ZAF	ZMB	ZWE					

Table 17: 134 countries used in Table 3

1 AGO	ALB	ARE	ARG	AUS	AUT	BDI	BEL	BEN	BFA
2 BGD	BGR	BHR	BOL	BRA	BRB	BWA	CAF	CAN	CHE
3 CHL	CHN	CIV	CMR	COD	COG	COL	COM	CPV	CRI
4 CYP	DEU	DJI	DNK	DOM	DZA	ECU	EGY	ESP	ETH
5 FIN	FRA	GAB	GBR	GHA	GIN	GMB	GNB	GNQ	GRC
6 GTM	HKG	HND	HTI	HUN	IDN	IND	IRL	IRN	IRQ
7 ISL	ISR	ITA	JAM	JOR	JPN	KEN	KHM	KOR	KWT
8 LAO	LBN	LBR	LCA	LKA	LSO	LUX	MAR	MDG	MEX
9 MLI	MLT	MMR	MNG	MOZ	MRT	MUS	MWI	MYS	NAM
10 NER	NGA	NIC	NLD	NOR	NPL	NZL	OMN	PAK	PAN

11 PER	PHL	POL	PRT	PRY	QAT	ROU	RWA	SAU	SDN
12 SEN	SGP	SLE	SLV	STP	SWE	SWZ	SYC	SYR	TCD
13 TGO	THA	TTO	TUN	TUR	TZA	UGA	URY	USA	VEN
14 VNM	ZAF	ZMB	ZWE						

Table 18: 122 countries used in Tables 11-13

1 AGO	ALB	ARE	ARG	AUS	AUT	BDI	BEL	BEN	BFA
2 BGD	BGR	BHR	BOL	BRA	BRB	BWA	CAF	CAN	CHE
3 CHL	CHN	CIV	CMR	COD	COG	COL	CRI	CYP	DEU
4 DNK	DOM	DZA	ECU	EGY	ESP	ETH	FIN	FRA	GAB
5 GBR	GHA	GMB	GRC	GTM	HKG	HND	HTI	HUN	IDN
6 IND	IRL	IRN	IRQ	ISL	ISR	ITA	JAM	JOR	JPN
7 KEN	KHM	KOR	KWT	LAO	LBR	LKA	LSO	LUX	MAR
8 MDG	MEX	MLI	MLT	MMR	MNG	MOZ	MRT	MUS	MWI
9 MYS	NAM	NER	NGA	NIC	NLD	NOR	NPL	NZL	PAK
10 PAN	PER	PHL	POL	PRT	PRY	QAT	ROU	RWA	SAU
11 SDN	SEN	SGP	SLE	SLV	SWE	SWZ	SYR	TGO	THA
12 TTO	TUN	TUR	TZA	UGA	URY	USA	VEN	VNM	ZAF
13 ZMB	ZWE								

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