Best-Practice Growth

and

Dynamic Efficiency

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ABSTRACT

The economic literature has not yet settled the issue of appropriate standards of efficiency for economic growth. Theoretical growth models predict growth rates dependent on many factors particularly initial capital levels, but they only weakly fit the empirical data, particularly in studies that rely on linear regressions. This paper proposes an alternative approach. It determines the best-practice growth frontier and then compares other countries' growth rates with those achieving best-practice growth. It finds that this best-practice growth frontier is supported by theoretical models, and that low-income countries are less dynamically efficient than previously thought.

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Introduction

In this paper, I attempt to reconcile two different approaches to understanding the sources of economic growth. One approach focuses on production and capital. Physical capital yields diminishing marginal returns, and therefore affords the possibility of high rates of growth when per capita capital levels are low, and low rates of growth when the levels are high. This basic result is tempered with complications due to levels of human capital, savings rates and underlying technological progress. Higher levels of human capital facilitate the adoption of new technologies. Higher, exogenously determined savings rates provide for the capital accumulation. Technological improvement might also be exogenously determined, or endogenously determined by the level of capital. This approach is exemplified by Mankiw, Romer and Weil's 1992 article "A Contribution to the Empirics of Economic Growth."

Another approach focuses on the institutions that create the environment for growth opportunities. Capital rich countries can and tend to grow faster than capital poor countries. Some countries use more efficient methods of production than do others, and yet these more efficient countries continue to search for even more efficient methods while the less efficient countries stagnate. Higher returns to capital investment in poor countries do not necessarily generate more investment in capital. Institutional failures or bad policies must be the core cause of lower growth rates. This approach is exemplified by Olson's 1996 article "Big Bills Left on the Sidewalk: Why Some Nations are Rich and Others are Poor."

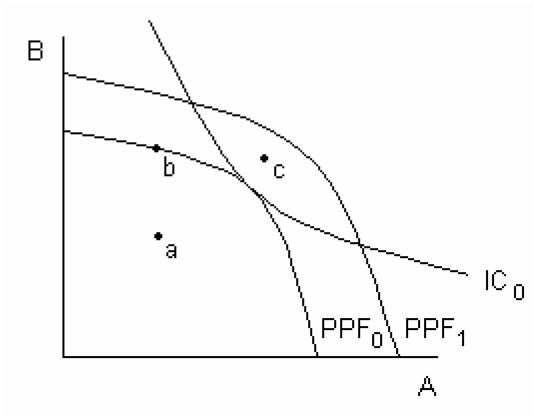
With the utmost respect for both of these approaches, I will attempt to delineate and unite the two approaches. Certainly levels of physical capital and institutions are important determinates of growth rates. In this paper I will attempt to show the contributions of per capita capital levels, and its limitations. Capital's contribution assumes perfect efficiency and therefore is exemplified by a *best-practice growth frontier*. Various institutions and policies yield inefficiency and are exemplified by *dynamic efficiency scores*. When viewed in this way, the contributions of both can be seen side by side.

In the rest of the paper, I will first define and justify the best-practice growth frontier and dynamic efficiency. Then I will look at the calculation and economic content of the best-practice growth frontier. This will be followed by a discussion of the calculation and economic content of the dynamic efficiency scores. I will conclude by summarizing the paper contents and suggesting further steps in the investigation of sources of growth and dynamic inefficiency.

Definitions and Theoretical Justifications

The best-practice growth frontier plots the highest growth rates achieved at each initial level of per capita output or capital. In order to generate a smooth curve such that the second derivative is of a constant sign, some of the observations are omitted. In order to generate a continuous curve, some plotted points are interpolated.

The best-practice growth frontier represents the potential growth rates of any country should it be able to replicate conditions of the best-practice countries. This efficiency standard is called dynamic efficiency. Any country with economic growth rates lower than the best-practice growth frontier suggests dynamic inefficiency.



Point a represents technical inefficiency.
Point b represents economic inefficiency.
Movement to point c in the second period represents dynamic inefficiency when the economy could have moved to a point on PPF_1.

Figure 1.

Certainly not all conditions that lead to best-practice growth are replicable. However, this standard represents an alternative to a standard based on regression analysis in which it is usually assumed implicitly that only the average performance is replicable. Which standard is more representative of the actual performance potential is still to be determined by empirical research.

It does seem to be easier to identify situations that one would reasonably expect to be replicable in other countries. The best macroeconomic policies could be adopted in other countries as many policy makers prescribe. Peace and property rights could be respected in more countries. Investment markets could be more efficient.

There appear to be very few situations leading to high economic growth that are not replicable. Discovery of vast natural resources certainly is not possible in all countries. However, this often leads to relatively long periods of increased GDP output, but only short term increases in growth rates.[1] In addition, such discoveries have been known to lead to Dutch disease and dependency, either of which seem to retard growth.

[1] In fact, this would seem to suggest that Data Envelopment analysis is more appropriate for the study of growth than the study of output despite commonly being used to study output but not used to study growth, at least as far as this author knows.

Much empirical research treats savings rates as exogenous, thereby implying that high savings rates are not replicable in all countries. (Barro 1999; Mankiw et al. 1992) Savings rates are partly determined by preferences for intertemporal substitution, which although replicable might not be part of an appropriate standard of efficiency. Yet preferences for intertemporal substitution should be considered endogenous because they could potentially shift as standards of living change. Likewise elasticities of intertemporal substitution should also be considered endogenous since they can potentially change with prices – i.e. interest rates.

More importantly, savings functions are not just determined by preferences by consumers for deferred consumption, but jointly determined by retained earnings, public savings and foreign savings. Levels of savings are not just determined by supply of savings, but also by demand for investment. Therefore, only a small factor determining the level of savings, preferences, should possibly not be considered reproducible, and consequently, the efficiency standard of the best-practice growth frontier should be applicable to other countries despite the subsumption of savings rates.

Best Practice Growth Frontier

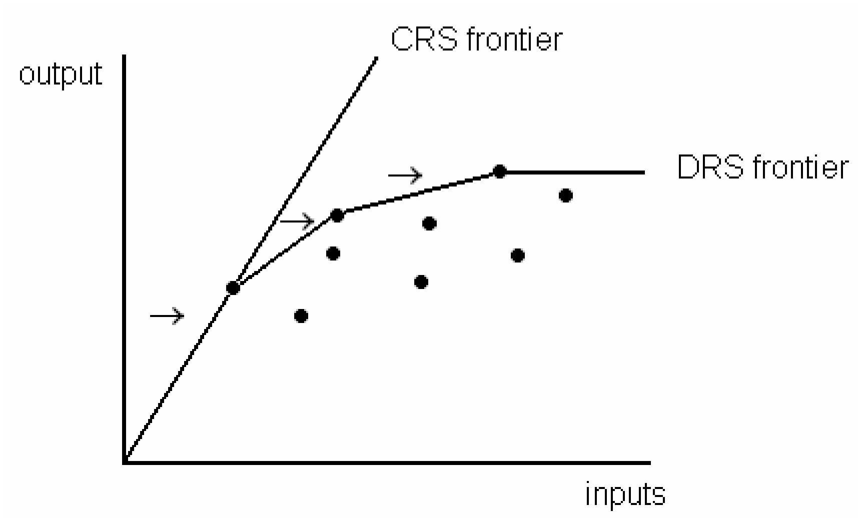
Calculation

In order to calculate the best practice growth frontier, I utilize a technique primarily used in economics to calculate production functions. This technique is data envelopment analysis (DEA).[2]

[2] See Kumar and Russell (2002) for a more technical and complete explanation of the process.

DEA is used to determine the frontier that generates the smallest convex cone to include all of the observed quantities of inputs and outputs. Software using standard mathematical programming algorithms is available to perform this task.[3] The effect is equivalent to taking a line along the vertical axis and pivoting it clockwise from the origin until it touches the first observation. This would assume constant returns to scale in production.

One can also assume decreasing returns to scale. In this case, essentially, one would continue to pivot the frontier with a kink at the first-touched observation. Once the kinked portion touches the second observation, the frontier is again kinked and



'CRS frontier' indicates the calculated frontier under assumptions of constant returns to scale when DEA is used to determine the production function. 'DRS frontier' indicates the corresponding frontier under assumptions of decreasing returns to scale.

Figure 2.

pivoted at this second observation. The process is continued until the last kinked portion has a zero slope without touching any more observations. (See Figure 2.)

[3] I used the *OnFront* software available from Economic Measurement and Quality i Lund AB, Box 2134, S-220 02 Lund, Sweden, www.emq.se.

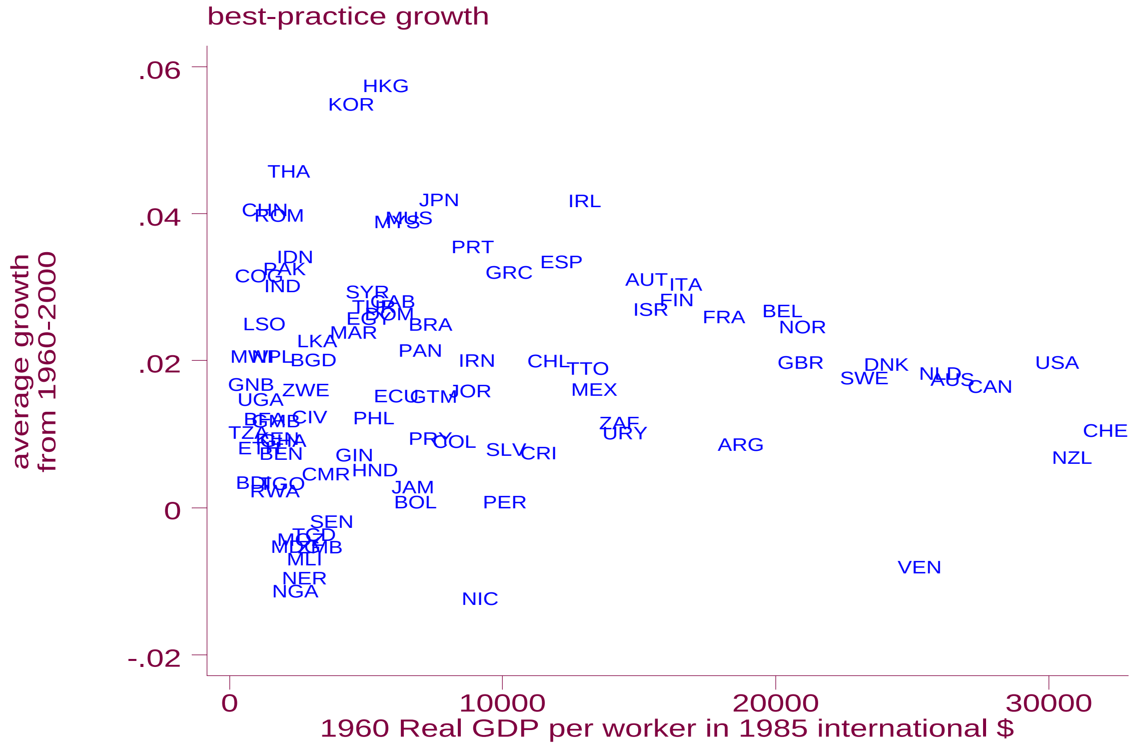
There are some fundamental ways that the plotted data of inputs and outputs are different from that of initial per capita capital and average subsequent rates of growth. (See Figure 3.) As a result of these differences, the data on initial per capita capital and rates of growth will have to be modified in order to utilize DEA. First, we should expect the production function to have a positive slope while if the costs to catching up are lowering than the costs to moving ahead, then the best-practice growth frontier should have a negative slope. Second, we should expect only non-negative values of output, but we can expect negative values for average growth rates. Third, a production function might not display increasing returns to scale and therefore not be convex, while the best-practice frontier could be strictly convex. The software that I use cannot calculate strictly convex frontiers. Therefore, I make several monotonic transformations of the data in order to calculate the best practice growth frontier with available DEA software.

The first modification is to enable a positive slope on the frontier despite the raw data indicating a negative slope on the frontier. This can be done by subtracting the initial output level for each country from a number at least as large as the largest initial output level. Ideally, this minuend should be the steady state value of output given the initial level of technology. However, it is unlikely that any estimate of this value will be accurate, and yet the subsequent results can be highly dependent on it.[4]

If the minuend is underestimated, then high initial output countries will be biased towards proximity towards the frontier and efficiency. If the minuend is overestimated, then just the opposite bias will occur. If the DEA assumption of constant returns to scale

[4] Actually, this would have to be adjusted for the fact that at the steady state level there should still be positive growth.

(i.e. the frontier has a constant slope) is used, then any error in estimating the minuend will distort the frontier and efficiency scores for low initial output countries as well.



In this graph, initial levels of GDP per worker are used as a proxy for initial per capita capital.
Figure 3.

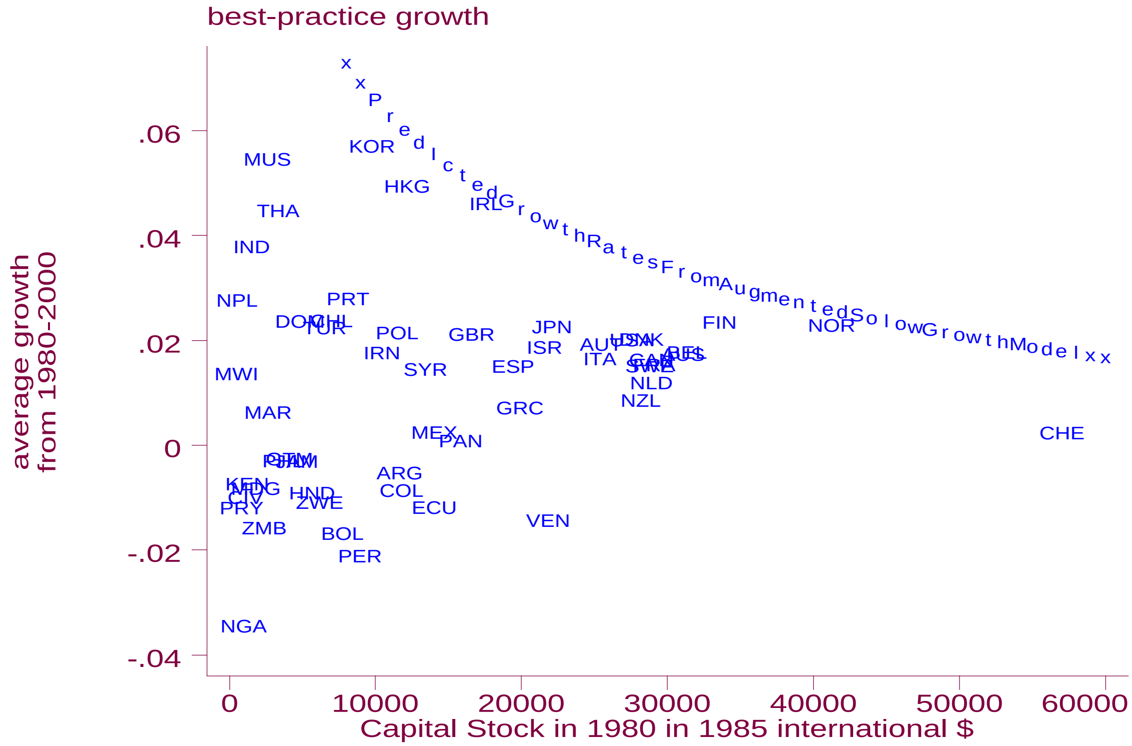
My solution is to create an artificial, high-initial-value pivot point such that the intermediate portion of the frontier is extended towards the high-initial-value countries. Likewise, I create an artificial, low-initial-value pivot point such that the intermediate portion of the frontier extends towards the low initial-value countries. This is combined with the use of a “decreasing returns to scale” (i.e. concave frontier) assumption. There is non-robustness, however the non-robustness only applies to the countries with very high or very low initial output values. Countries with initial values between those of countries that lie on the frontier will not be affected.

The second modification is to create all positive values for average growth rates (analogous to only positive output values in the calculation of a production function). I do this by subtracting the lowest value of average growth (in all cases a negative number) from each country's average growth rate. The rescaling does not affect the calculation of the frontier, but it will affect the cardinal values of efficiency scores.

The third modification is to transform the best-practice frontier from a convex function to a concave one. There are two possible routes to take: One is theoretically based, and the other is data driven. A theoretically based modification would assume a production function, derive the subsequent convergence function, and then algebraically manipulate the function so that it is linear in initial output. A second approach would be to rescale the initial output values with a nonlinear monotonic transformation so as to maximize the number of observations lying on the frontier with a DEA assumption of constant returns to scale (i.e. constant slope).

I use a combination of the two approaches. I linearize the observations based on the implications of a Cobb-Douglas production function, the parameter α set to 2/3 as determined by Mankiw, Rover and Weil's augmented Solow Growth model that has positive externalities from capital yet retains diminishing marginal returns.[5] Visually, this particular value of the parameter α seems to generate the best fit.

However, this tends to over compact the observations in part because the theoretical frontier is based on yearly growth rates but the data are of average growth rates over a few decades. Thus the measured average growth rates should not be as high as theoretical yearly growth rates. Now, instead of generating a theoretically linear frontier, I have generated a theoretically concave frontier. However, I then use the DEA assumption of decreasing returns to scale (i.e. concave frontier), which has the effect of correcting for the over compaction of the data. Because of the DEA assumption of decreasing returns to scale, more observations are potentially included on the frontier as would be the case in a data driven approach.



The curve labeled 'xxPredictedGrowthRatesFromAugmentedSolowGrowthModelxx' shows a possible best practice frontier.
Figure 4.

Economic Content

The best practice growth frontier shows the most efficient relationship achieved between initial levels of per capita capital and growth rates. This means that

[5] The actual transformation I use is: adjusted growth rate = $(g + n + \delta)^{1/(\alpha-1)}$, where g = observed average

savings rates would likely be high, population growth rates low, institutions working efficiently, and economic policies effective. Investment markets would be efficient and production would be getting more efficient.

Any positive or negative effects of capital level on growth rates should be contained in the frontier. If diminishing marginal returns to capital are present, then the frontier should slope downward, just as it in fact does. However, if there are externalities to capital levels present, then any downward slope should be mitigated. If the effects of the externalities are greater than the effects of diminishing marginal returns, then the frontier should be upward sloping. It is not.

However, that is not to say that there are not positive externalities present. It needs to be determined. The stronger the diminishing marginal returns, then the more steeply negative will be the slope. The stronger any positive externality, then the more steeply positive will be the slope. In order to separate the two tendencies, at this point assumptions must be made.

If markets are competitive, then we should expect entry until there are constant returns to scale. In this case, the Cobb-Douglas production function, $Y = AK^{\alpha}L^{(1-\alpha)}$, might be appropriate, where Y is output, K is capital, L is labor, α is a parameter determining the rate of diminishing marginal returns, and A is a residual. If factors of production are paid their marginal products, then α would equal 1/3, at least for the U.S. economy. The larger is α, then the stronger the diminishing marginal returns, and the steeper the slope.

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growth rate, n = population growth rate = 0.02, δ = depreciation rate = 0.06, α = capital factor share = 2/3.

However, this appears to be too steep for the best practice frontier. This slope seems to conform to a value of α equal to 2/3. This might indicate the presence of positive externalities to capital stock with diminishing marginal returns.[6,7]

But, a production function can fit the data well and still not be a representation of the underlying relationship. The data might show that particular combinations of labor and capital are associated with particular levels of output, and yet the causation actually takes an indirect route. In particular, the best practice growth frontier could actually contain information regarding the spread of technology, even though the frontier is a function of capital stock.

In many cases, a simplifying assumption is made that technology is a pure public good. This is certainly not the case for at least a couple of reasons – technology is embodied in capital or labor, and the dissemination of technology is costly.

Thus there is a strong relationship between technology and capital. If a producer or a country wishes to use the latest technology, then typically it will need to invest in new capital. Likewise, if a firm invests in new capital, it will, in many but not all cases, acquire the latest technology.

So, by showing the relationship between capital and growth, the best-practice growth frontier is also showing a relationship between technology and growth, and again, this relationship fits with a downward sloping frontier. Wealthy countries face higher costs to grow – they must invent the new technology and invest in the new capital that

[6] This reasoning follows that of Mankiw, Romer and Weil in their 1992 paper.
[7] Also note that the frontier seems to be convex as would be predicted by diminishing returns that more slowly decay as they reach their steady state without technological progress, as do those in the Cobb-Douglas production function.

uses it. Poor countries can grow without as much invention. They can buy existing capital with the latest, best, world technology, and not only increase their capital stock, but also improve their level of technology.

There might be other variables that affect growth rates and are represented by the best-practice growth frontier, but more likely other variables will affect dynamic efficiency.

Dynamic Efficiency

Calculation and Results

Dynamic efficiency for each country can be represented by the relative distance to the frontier. This is the ratio a/(a+b) as represented in Figure 5. Countries closer to the frontier have higher efficiency scores. This measure is known as the Farrell output-based efficiency index.

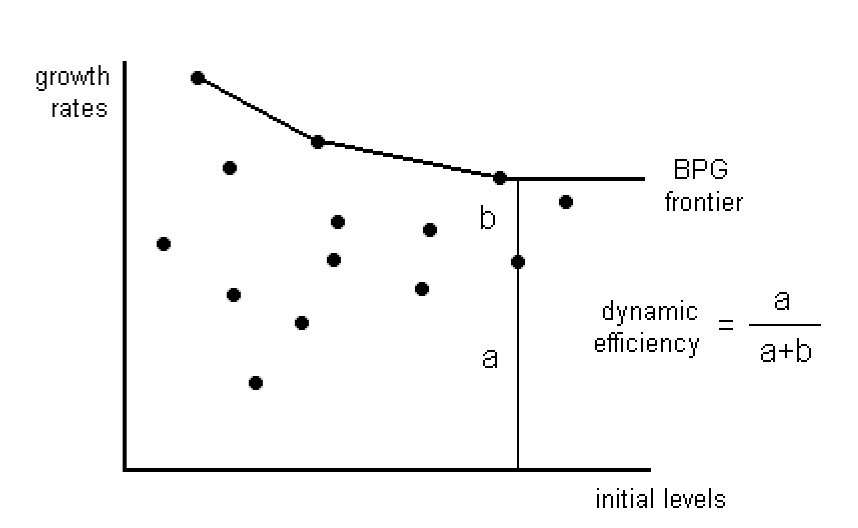

Figure 5.

Because of the rescaling of the raw data, all subsequent efficiency scores are relative between the country with the slowest growing economy (negative growth), and the best-practice frontier. Thus the country with the slowest growth will always have an efficiency score of 0, and all countries on the frontier will have scores of 1. Since the rate of slowest growth will likely be different with different data sets, the efficiency scale will also change between data sets. This makes comparisons of efficiency difficult between different data sets, unless of course all calculations are made using the overall slowest rate of growth as the same base.

In order to minimize the chance that super efficient countries determine the frontier, all countries with a population of less than one million are excluded from the calculations. The reasoning is that positive errors are more likely with smaller countries.

For example, Luxembourg would be on the frontier were they not excluded due to their small population. It might be reasonable to exclude Luxembourg because they have had advantages for high growth rates that are probably not available to other countries. A large proportion of their recent growth has come from the banking sector as many depositors have taken deposits out of Swiss banks and into Luxembourgian banks and hence contributing to local profits and GDP. If the same funds had gone into French banks, it probably would not have significantly contributed to growth rates.

Also, much of the Luxembourgian workforce is foreign labor that commutes from neighboring countries. Because of this, part of the investments made by neighboring countries in human capital, benefit Luxembourg. So, Luxembourg has the advantage that it does not have to invest so heavily in human capital. That is done for them by the

Belgians, Germans and French. Also, if profits are reinvested at a higher rate than wages, or if only part of the taxes go to the workers home countries, then that will give the Luxembourgian higher investment rates, and hence higher growth rates.

The dynamic efficiency index results based on various data sets are included as appendices. Appendix C summarizes the efficiency scores when the initial variable is capital per worker in the year 1980 and the average growth rate is of per worker output from 1980 to 2000. Appendix D summarizes the efficiency scores when the initial variable is output per worker in 1980 and the average growth rate is of output per worker from 1980 to 2000. Appendix E summarizes the efficiency scores when the initial variable is output per worker in 1960 and the average growth rate is of output per worker from 1960 to 2000.

Since the efficiency scores are relative, interpreting them must be done by comparisons. One obvious way to compare scores is between countries. The countries that help determine the frontier in at least one data set are Ireland, the Republic of Korea, Norway, Hong Kong, and the United States. Other high-efficiency countries are Mauritius, Switzerland, China, and Japan. None of these countries are anomalous although for some of them their success may not be replicable for most countries. Hong Kong and Mauritius have benefited from unique geographic positions that have allowed them to grow as global trade grew. Note that Taiwan and Singapore are missing from the data sets.

Some of the least efficient countries are Nigeria, Nicaragua, Chad, Zambia, Bolivia, Paraguay, Mali, and Mozambique. There are many more countries that are nearly as inefficient. Most of these countries are notoriously poor, and many of them were involved in internal warfare at one point or another during the period of analysis. Again, a casual observation suggests that these results are consistent with the historical record.

Another possible comparison is between the dynamic efficiency rankings and general growth rate rankings. On might suspect that many of the fastest growing countries will not appear as efficient when they are expected to be growing faster as a result of a downward sloping best practice growth frontier. This is indeed the case. On average countries from the top third in terms of growth rates move down eleven places when ranked by the dynamic efficiency scores. (See Appendix D. Note that there are 93 countries in total.) For example, China moves down from first place to sixth place. On average, countries from the bottom third in terms of growth rates move up 13 places.

One would also expect the countries with the highest levels of per capita capital to move up in rankings when ranked by dynamic efficiency scores instead of average growth rates. Countries from the top third in terms of initial capital per worker move up on average 7 places. (See Appendix C. Note that there are 54 countries in total.) Switzerland moves up 27 places. Countries from the bottom third in terms of initial capital per worker move down on average 2 places.

One would expect the dynamic efficiency scores, as measured in this paper, to be strongly correlated with the productivity efficiency scores as measured by Kumar and

Russell (2002).[8] However, the correlation coefficient is only 0.59. (See Appendix F.) Some of the countries that appear more efficient in terms of productivity are Paraguay, Morocco, the Netherlands, and the United Kingdom, which have rankings higher by 43, 22, 16, and 16 places, respectively. Countries that appear more efficient in terms of dynamic efficiency are the Republic of Korea, Thailand, Denmark, and Japan. They rank 28, 25, 15, and 15 positions higher, respectively. By this small sample, the dynamic efficiency scores do not seem to generate as many anomalies. Possibly poor countries grow quickly and catch up, they do not necessarily incorporate the most labor efficient technologies immediately. This would make sense while wages are still low.

One needs to consider how dependent these results are on the initial variable chosen or the time period chosen. When per worker output instead of per worker capital is chosen as the initial variables (1980), there are only modest changes in ranking. (See Appendix G.) Out of 53 countries, on average countries moves up or down 5.9 positions. Some of the countries that rank better in terms of initial capital are Indonesia, Nepal, and Finland, which are consequently 22, 18, and 14 positions higher. Some of the countries that rank better in terms of initial output are the Netherlands, New Zealand, and Argentina, which are consequently 17, 13, and 12 positions higher. Possibly, if human capital were to be included in the measurement of physical capital, these inconsistencies might disappear. Also, note that much of the theory of convergence, which would predict a downward sloping frontier, is based on transitory convergence resulting from capital accumulation. Initial output levels might be serving as a proxy for initial capital levels, but they might also proxy for other factors such as technology levels or institutions.

[8] I use the productivity efficiency score from this paper instead of the paper by Henderson and Russell (2002), because human capital is excluded, as it is also excluded in the convergence efficiency scores.

Comparisons between initial per capita output in 1980 versus 1960 fare about the same. (See Appendix G.) Out of the 53 countries, on average a country moves up or down 5.5 positions. Some of the countries that appear more efficient with the 1960 starting period are Japan, Portugal, and Indonesia, which rank higher by 18, 13, and 11 positions, respectively. This is probably consistent with the facts. For example, Japan had much higher growth rates in the 1960's and 1970's than in the 1990's; yet not all of this slowdown can be explained by convergence and catch up. Some of the countries that appear more efficient with the 1980 starting point are Canada, the Netherlands, and Venezuela, which rank higher by 17, 17, and 14 positions, respectively. The Venezuelan economy experienced a very rapid decline in the 1970's. The other countries mentioned here might have similar explanations for their poorer performance with the inclusion of the two earlier decades in the analysis.

Economic Content – Sources of Growth

There are many sources of growth. The best-practice growth frontier should show the effect of capital accumulation, both directly and indirectly in the case of technology. The dynamic efficiency scores should show the rest.

The sources of growth have been the topic of much economic research for centuries. Here I will merely try to summarize the key aspects in order to facilitate the economic reasoning. Since I do not verify the contributions to growth of any factor, I do not imply proof of particular sources of growth. My purpose is to show the potential research into the content and sources of dynamic inefficiency, and deductively, sources of growth.

I will divide the sources of growth into several categories. The two main categories are direct increases in production and indirect increases in production. Direct increases include increases in inputs, increases in the efficiency with which the inputs are used, and increases in the efficiency with which goods are traded. Indirect increases involve the incentives to increase production. They include hyper profitability, hypo profitability and the efficiency of markets for investment in production.

Indirect increases in production -- i.e. incentives -- are probably the area of greater interest in the current debate within the literature. Shahid Husuf and Joseph E. Stiglitz have recently declared the issues of (direct) sources of growth to have been resolved "although academic skirmishes continue", and the effects of governance and regulation to be an "issue for the 21st century." (Yusuf at al 2000) Edward Glaeser et al. have provided empirical evidence to doubt the importance of institutions and their constraints on the executive, but have shifted the issue instead to policies (of the executive). (Glaeser at al. 2004) The importance of institutions and policies has yet to be resolved, and we might find new answers by looking at dynamic efficiency instead of economic growth rates.

The indirect increases can sustain the direct increases in production. The direct increases by themselves are transitory in growth even though they are sustainable in production. However, when incentives are increased, then growth might be increased indefinitely. Since incentives are so potentially important to growth, research into them might prove particularly fruitful and worth the effort.

Typically, we consider three types of inputs: physical capital, labor and natural resources. Increases in the quantity of capital are obviously included in the best-practice growth frontier and not in the dynamic efficiency scores.

Increases in the quantity of labor are included if it does not come from population increases since the variables are per capita variables. So, if the labor force participation rate increases, then it should lead to temporary growth.[9] This could happen as women enter the labor force, if child labor increases, or if military personnel or the institutionalized enter the labor force. Also, if workers work more hours per week or take fewer vacations or sick leave, then there will be temporary growth. Any of these scenarios would contribute to a higher growth rate, but they are not sustainable sources of growth. The economic participation rates vary quite a bit from less than 50% in Iraq to about 75% in Iceland. (UNDP 2000)

It is possible that increases in the labor force participation rate would lead to sustainable increases in growth rates. For example, some say that the more people in the workforce, the more likely there are to be contributors to progress through invention etc. (Griffin 1997) Thus an increase in the labor force participation rate could lead to higher rates of technological progress and therefore higher steady-state growth rates. If this is true, then it would be considered a part of dynamic efficiency. But getting people to work longer hours per week, for example, should not be considered increased efficiency, particularly if the workers feel that the opportunity costs of more hours is too high.

Increases in the quantity of natural resources could also increase growth rates. Although most likely more raw materials would require more labor and capital in order to produce more goods, if the raw materials are used for energy, then they can substitute for labor. But the relevant issue here is that the increase in growth rates would likely be temporary, and thus not a source of dynamic inefficiency. They would not likely increase the rates of growth in the long term.

Inputs can also increase in quality and result in higher productivity, which will lead to temporary growth but not necessarily sustained growth. Capital can increase in quality leading to higher productivity or lower depreciation rates. If there are positive externalities to higher levels of technology -- for example, higher levels of technology lead to higher human capital levels, which in turn lead to higher rates of technological progress -- then increases in technology can generate higher sustained growth rates. To whatever extent that levels of technology are associated with levels of per capita output or capital, this will have more effect on the slope of the best-practice growth frontier, than it will on dynamic efficiency.

Human capital levels should be considered a potential source of dynamic inefficiency. Not only can more human capital lead to greater rates of technological change, but they can also be necessary to utilize existing levels of technology. Thus they can enable economies to grow at their potential rates. The literature on the importance of human capital is voluminous and seemingly unabating. (For a recent example see Glaeser at al 2004)

Increases in the quality of natural resources are probably not a source of dynamic inefficiency. They probably only lead to short-term increases in growth rates, not sustainable ones. Dutch disease and dependence seem to inhibit growth in many

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[9] This is not applicable to scores based on initial levels of capital stock per worker.

countries. Jeffrey D. Sachs and Andrew M. Warner have provided empirical evidence for a negative relationship between natural resource endowments and growth rates. (Sachs et al. 2000)

Increases in static efficiency can lead to short-term growth. One source of increased static efficiency is due to the appropriate number of producing firms resulting in production at the minimum efficient scale. Free market entry and free trade are ways to generate optimal firm size.

Reductions in transaction costs have two effects. One is to lower the costs to society of bringing the natural resources to the consumers in the form of final goods. This cost could end up being a buyer's cost, seller's cost, or a shared cost. The other effect is to increase the market size. In this case, it is more likely that the minimum efficient scale will result when there are initially increasing returns to scale. In extreme cases, markets will not exist in the presence of high transaction costs.

The most important sources of dynamic inefficiency likely relate to incentives. If the incentives are wrong, then self-serving economic agents will not invest in increases in productivity. Typically, we think of this as providing property rights and getting prices right. But this suggests that the benefits to the investor are the same as the benefits to society. In these situations we need an agent to act on behalf of society -- i.e. owner -- and use accurate information -- i.e. prices -- in order to make the most efficient decision. However, far too often the profits to the investor are very different from the profits to society.

If the potential profits to the investor exceed those to society, then for shorthand and emphasis I call these hyper profits. An extreme example is theft. While the returns to the thief could be positive or negative, the returns to society will nearly always be negative. Society does not gain assets, but only loses them, in particular the tools and time of the thief, and the locks of the original owner.

A less extreme example would be any typical large firm. Most likely the firm will directly, or indirectly through a trade organization, lobby the government for beneficial treatment. In these instances, the benefits to the firm are higher than the benefits to society.

These are examples of what is alternatively called rent seeking or directly-unproductive-profit seeking. In these examples, there are three types of inefficiencies: economic inefficiencies, technical inefficiencies and dynamic inefficiencies. Economic inefficiencies result because there is less total production as a result of the rent seeker. Non-thieves have less incentive to hold assets, and consumers buy fewer goods due to the tariffs. This is can be seen in the deadweight loss of Harberger's triangle. (Harberger 1954)

Technical inefficiencies are apparent since costs are higher due to expenses that do not contribute to production. This is one way of viewing Krueger's rent-seeking costs. (Krueger 1974; Murphy et al. 1993) Another way of viewing Krueger's rent-seeking costs is not as a one-time opportunity cost of production, but as a recurring opportunity cost of investment. In this case, the rent seeking generates dynamic inefficiency.

This is potentially a major source of dynamic inefficiency. Sources of hyper profits abound. Transfers of assets, market power or political power are all instances where private profits do not necessarily contribute to a nation's output. (Khan at al. 2000) There is much literature on the theoretical effects of rent seeking on static and dynamic efficiencies. (Krueger 1974; Buchanan et al. 1980; Murphy at al. 1993)

Other sources of over investment due to hyper profits result from negative externalities. While negative externalities can lead to rent seeking, they are social inefficient even without it. However, in these cases they probably do not lead to large dynamic inefficiencies, although as they lead to too much investment in the production of one product, they must be taking away investment from other potentially more socially beneficial areas, and therefore lead to some dynamic inefficiency.

Situations in which the social benefits exceed the private benefits from investment are also common throughout the world. As shorthand I will refer to them as hypo profits. Positive externalities can lead to hypo profits. In this case, there is too little investment. Investment in human capital is a case when the presence of positive externalities can lead to dynamic inefficiency.

Another form of hypo profits is coordination failures. There are two basic types, those relating to supply and those relating to demand. When there are coordination failures relating to supply, a firm's costs are prohibitively high because other firms are not supplying the inputs. It might not be profitable for the input user to produce them herself if these inputs have large fixed costs and would also be used as inputs by other firms.

Coordination failures can also occur with respect to demand. In this case, there is no demand for the final output because workers' incomes are low. Firms would need to capture more of the surplus that workers and consumers capture, in order to make the investment profitable.

Coordination failures certainly could result in dynamic inefficiency. There is much theoretical literature. (Murphy et al. 1989; Rodrick 1996) Stephen Ferris and Kishore Gawade develop a measure of coordination failures in emerging countries. (Ferrris et al. 2003).

Finally, transaction costs for investment capital can lead to dynamic inefficiency. In these instances the higher costs reduce the amount of investment and result in slower rates of growth indefinitely. There is also much literature on the effects of imperfect capital markets. (for a general summary see Ray 1998)

While the theoretical literature on sources of dynamic inefficiencies is vast, it deserves to be reexamined using best-practice growth as the efficiency standard. Since when using this standard, poor countries tend to appear less efficient this means that economists have heretofore underestimated the detrimental effects of the importance of appropriate incentives and other sources of underperformance.

Summary

Benefits of Investigating Best Practice Growth Frontiers and Dynamic Efficiency

Since most of the conditions that lead to growth, or the lack of it, can potentially be replicated in other parts of the world, then it can be useful to use the situations in which growth rates are the highest as the standards for comparison. Since initial levels of capital can affect the opportunities for growth, and yet are dependent on past growth, it is appropriate to make the growth-rate standards dependent on initial per capita capital or output levels. This relationship between initial capital levels and highest growth rates achieved is constructed as the best-practice growth frontier.

Economies that are not realizing potential growth rates are dynamically inefficient. Some of the major sources of dynamic inefficiency are too much investment in hyper profits, and not enough investment in hypo profits. In particular, rent seeking inefficiencies can result from the pursuit of hyper profits, and coordination failures can lead to hypo profits and dynamic inefficiency.

In addition to the theoretical advantages of this dichotomy, the empirical results seem to be intuitively sensible. Countries such as South Korea and the United States, which are often seen as positive examples of economic performance, score high in dynamic efficiency even if they do not score well in terms of productive efficiency or absolute growth rates. Countries, such as Argentina and Nigeria, that do not score well in terms of dynamic efficiency also seem inefficient from the general perspective.

Further Research

This approach also creates opportunities for continued research. What is the relative empirical importance of the various sources of dynamic inefficiencies? Two possibly critical sources are rent seeking of hyper profits and under investment where there are hypo profits due to coordination failures. One proxy for the hyper profits is corruption. In fact, perceived corruption levels correlate highly with dynamic efficiency scores. Coordination failures could be measured in terms of governments' involvement in industrial policies.

Also, this view of the sources of growth could add new insight to debates over convergence. The best-practice growth frontier shows absolute convergence. However, since most countries fall below a convergence threshold, on average there is not convergence due to dynamic inefficiencies. In other words, diminishing returns to capital and lower costs to incorporate existing technologies rather than create them results in opportunities for convergence, but they are not captured, possibly due to corruption and coordination failures.

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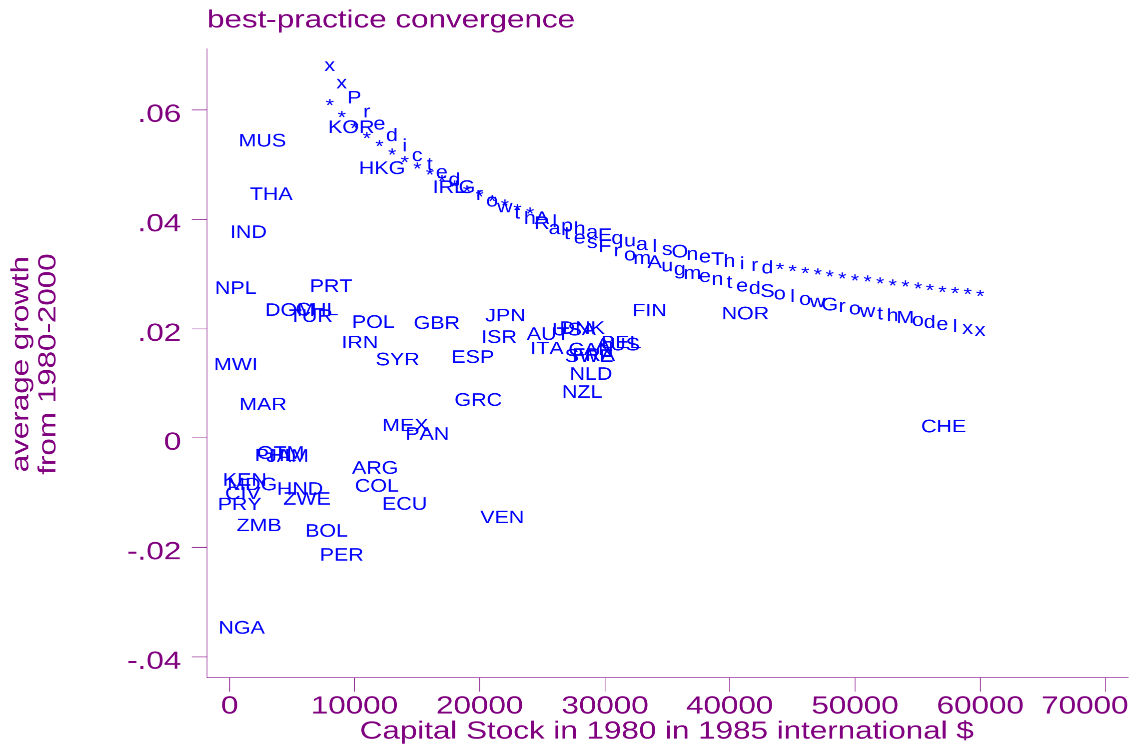
Appendix A.

The data are for 90 countries. Countries were included if they had available data for GDP per worker in the years 1960 and 2000 and they had populations in the year 2000 over 1 million.

ARG	Argentina
AUS	Australia
AUT	Austria
BDI	Burundi
BEL	Belgium
BEN	Benin
BFA	Burkina Faso
BGD	Bangladesh
BOL	Bolivia
BRA	Brazil
CAN	Canada
CHE	Switzerland
CHL	Chile
CHN	China
CIV	Cote d'Ivoire
CMR	Cameroon
COG	Republic of Congo
COL	Colombia
CRI	Costa Rica
DNK	Denmark
DOM	Dominican Republic
ECU	Ecuador
EGY	Egypt
ESP	Spain
ETH	Ethiopia
FIN	Finland
FRA	France
GAB	Gabon
GBR	United Kingdom
GHA	Ghana
GIN	Guinea
GMB	Gambia
GNB	Guinea-Bissau
GRC	Greece
GTM	Guatemala
HKG	Hong Kong
HND	Honduras
IDN	Indonesia
IND	India
IRL	Ireland
IRN	Iran
ISL	Iceland
ITA	Italy
JAM	Jamaica
JOR	Jordan
JPN	Japan
KEN	Kenya
KOR	Republic of Korea
LKA	Sri Lanka
LSO	Lesotho
MAR	Morocco
MDG	Madagascar
MEX	Mexico
MLI	Mali
MOZ	Mozambique
MUS	Mauritius
MWI	Malawi
MYS	Malaysia
NER	Niger
NGA	Nigeria
NIC	Nicaragua
NLD	Netherlands
NOR	Norway
NPL	Nepal
NZL	New Zealand
PAK	Pakistan
PAN	Panama
PER	Peru
PHL	Philippines
PRT	Portugal
PRY	Paraguay
ROM	Romania
RWA	Rwanda
SEN	Senegal
SLV	El Salvador
SWE	Sweden
SYR	Syria
TCD	Chad
TGO	Togo
THA	Thailand
TTO	Trinidad &Tobago
TUR	Turkey
TZA	Tanzania
UGA	Uganda
URY	Uruguay
USA	USA
VEN	Venezuela
ZAF	South Africa
ZMB	Zambia
ZWE	Zimbabwe

Appendix B.

Predictions by the Solow Growth model and the Cobb-Douglas production function, where $\alpha = 1/3$, and $\alpha = 2/3$.



The key difference between the two theoretical frontiers is the steepness. The key variable that influences the slope is the value for α. On the curve labeled "Alpha Equals One Third," the slope appears to be too flat to provide a good fit with the data. For this curve, others values are savings rate equals 0.30, the level of technology equals 1500, the population growth rate equals 0.02, and the depreciation rate equals 0.065. These variables affect the level of the curve. 1500 is approximately the technology level of the United States.

For the curve labeled "Predicted Growth Rates From Augmented Solow Growth Model," α equals 2/3, and there seems to be a better fit of curvature. Other values are savings rate equals 0.25, the level of technology equals 26, the population growth rate equals 0.02, and the depreciation rate equals 0.10.

The values for variables other than α are estimated from data on six countries that are close to the frontier as summarized in the following table:

country	per capita GDP	per capita capital	A when α equals 2/3	A when α equals 1/3	savings as % of output	investment as % of output
Finland	31222	33564	30	968	30.2	28.7
Ireland	26926	17585	39	1035	7.3	22.0
Norway	34998	41244	29	1013	38.2	30.7
South Korea	12395	9759	27	580	27.5	32.9
Switzerland	46121	57061	31	1198	27.9	28.9
United States	44217	27551	48	1464	22.4	22.9

The numbers above may not jibe for several reasons. First, GDP is measured in 1990 international dollars, and capital is measured in 1985 international dollars. The reason for this difference is that, since the 6.1 version of the Penn-World tables did not yet have data on capital available, version 5.6 is the source used for capita data and version 6.1 for all other data. Note that this inconsistency should not affect average growth rates.

Second, when α equals 2/3, one should include values for human capital when estimating the parameter A. Note, however, that these inconsistencies will only affect the level of the theoretical frontier, not the curvature. The only subsequently used result is the parameter α. The level of the frontier will be based on the observations themselves.

Appendix C.

Efficiency Index based on initial per worker capital in 1980, and average growth rates of per worker output from 1980 to 2000.

Rank - Efficiency	Country	Dynamic Efficiency	Rank - capital	Avg. Growth	Rank - Growth
1	Norway	1.00	2	2.20%	12
1	Ireland	1.00	20	4.51%	4
1	Republic of Korea	1.00	31	5.60%	1
4	Hong Kong	0.94	26	4.85%	3
5	Mauritius	0.85	45	5.36%	2
6	Finland	0.74	3	2.25%	11
7	Thailand	0.73	43	4.38%	5
8	Indonesia	0.62	48	3.69%	6
9	Switzerland	0.58	1	0.14%	36
10	Belgium	0.55	4	1.67%	21
11	Australia	0.54	5	1.63%	23
11	Denmark	0.54	10	1.93%	17
13	USA	0.53	12	1.91%	18
14	Portugal	0.50	33	2.70%	7
15	Japan	0.49	15	2.16%	13
16	Canada	0.48	8	1.53%	25
16	Austria	0.48	13	1.83%	19
18	France	0.46	6	1.43%	26
19	Sweden	0.45	9	1.42%	27
20	Italy	0.43	14	1.55%	24
20	Israel	0.43	17	1.77%	20
20	Nepal	0.43	53	2.67%	8
23	United Kingdom	0.41	21	2.02%	16
24	Chile	0.38	35	2.28%	9
25	Netherlands	0.37	7	1.09%	31
25	Poland	0.37	29	2.04%	15
27	Dominican Republic	0.36	39	2.27%	10
28	Turkey	0.35	36	2.14%	14
29	Spain	0.34	19	1.40%	28
30	Iran	0.32	30	1.66%	22
31	Syria	0.29	25	1.35%	29
32	New Zealand	0.27	11	0.76%	32
33	Malawi	0.22	54	1.26%	30
34	Greece	0.18	18	0.62%	33
35	Morocco	0.11	44	0.53%	34
36	Mexico	0.04	23	0.15%	35
37	Venezuela	0.02	16	-1.53%	50
37	Panama	0.02	22	-0.01%	37
37	Ecuador	0.02	24	-1.28%	48
37	Colombia	0.02	27	-0.96%	44
37	Argentina	0.02	28	-0.63%	41
37	Zimbabwe	0.02	37	-1.19%	47
37	Honduras	0.02	38	-1.01%	45
37	Jamaica	0.02	40	-0.40%	40
37	Guatemala	0.02	41	-0.36%	38
37	Philippines	0.02	42	-0.39%	39
37	Madagascar	0.02	47	-0.92%	43
37	Kenya	0.02	49	-0.84%	42
49	Peru	0.01	32	-2.21%	53
49	Bolivia	0.01	34	-1.78%	52
49	Zambia	0.01	46	-1.67%	51
49	Cote d'Ivoire	0.01	50	-1.09%	46
49	Paraguay	0.01	52	-1.30%	49
54	Nigeria	0.00	51	-3.55%	54

Data Source: Penn-World Tables versions 5.6 and 6.1

Appendix D

Efficiency Index based on initial per worker output in 1980, and average growth rates of per worker output from 1980 to 2000.

Rank - Efficiency	Country	Dynamic Efficiency	Rank - Real GDP	Avg. Growth	Rank - Growth
1	Republic of Korea	1.00	46	5.60%	2
1	Ireland	1.00	20	4.51%	5
3	Hong Kong	0.94	28	4.85%	4
4	Switzerland	0.90	1	0.14%	58
5	Mauritius	0.88	48	5.36%	3
6	China	0.86	86	5.94%	1
7	USA	0.56	2	1.91%	30
8	Thailand	0.46	60	4.38%	6
9	Malaysia	0.41	45	3.99%	7
10	Netherlands	0.35	3	1.09%	46
11	Belgium	0.31	4	1.67%	33
12	Italy	0.26	5	1.55%	36
13	Uganda	0.24	92	3.76%	8
13	Canada	0.24	6	1.53%	37
15	India	0.23	75	3.69%	9
16	Australia	0.21	7	1.63%	35
17	France	0.20	8	1.43%	39
18	Norway	0.18	10	2.20%	22
18	Austria	0.18	9	1.83%	31
20	Denmark	0.17	11	1.93%	28
21	Romania	0.16	66	3.47%	10
21	Sweden	0.16	12	1.42%	40
23	Spain	0.15	14	1.40%	41
23	New Zealand	0.15	13	0.76%	48
25	Finland	0.14	15	2.25%	20
26	Bangladesh	0.13	70	3.38%	11
26	United Kingdom	0.13	18	2.02%	27
26	Israel	0.13	17	1.77%	32
26	Greece	0.13	16	0.62%	49
30	Japan	0.10	22	2.16%	23
30	Argentina	0.10	19	-0.63%	69
32	Portugal	0.09	27	2.70%	15
32	Trinidad &Tobago	0.09	21	0.10%	60
34	Hungary	0.08	32	2.10%	25
34	Mexico	0.08	25	0.15%	57
34	South Africa	0.08	24	-0.45%	68
37	Chile	0.07	33	2.28%	18
37	Poland	0.07	43	2.04%	26
37	Iran	0.07	40	1.66%	34
37	Tunisia	0.07	37	1.50%	38
37	Brazil	0.07	31	0.48%	51
37	Uruguay	0.07	26	0.14%	59
37	Gabon	0.07	29	-0.42%	67
44	Pakistan	0.06	67	2.98%	12
44	Sri Lanka	0.06	65	2.92%	13
44	Indonesia	0.06	61	2.86%	14
44	Dominican Republic	0.06	49	2.27%	19
44	Egypt	0.06	55	2.20%	21
44	Turkey	0.06	52	2.14%	24
44	Syria	0.06	47	1.35%	43
44	Morocco	0.06	50	0.53%	50
44	El Salvador	0.06	44	0.36%	54
44	Panama	0.06	34	-0.01%	62
44	Costa Rica	0.06	35	-0.35%	63
44	Guatemala	0.06	38	-0.36%	64
44	Jordan	0.06	30	-0.64%	70

Data Source: Penn-World Tables versions 5.6 and 6.1

44	Venezuela	0.06	23	-1.53%	84
58	Nepal	0.05	83	2.67%	16
58	Guinea-Bissau	0.05	93	2.55%	17
58	Burkina Faso	0.05	89	1.93%	29
58	Guinea	0.05	63	1.36%	42
58	Malawi	0.05	87	1.26%	44
58	Benin	0.05	85	1.17%	45
58	Lesotho	0.05	78	1.02%	47
58	Senegal	0.05	73	0.38%	52
58	Mozambique	0.05	84	0.37%	53
58	Gambia	0.05	79	0.20%	56
58	Republic of Congo	0.05	68	0.01%	61
58	Philippines	0.05	54	-0.39%	65
58	Jamaica	0.05	56	-0.40%	66
58	Colombia	0.05	41	-0.96%	77
58	Ecuador	0.05	39	-1.28%	82
58	Paraguay	0.05	42	-1.30%	83
74	Ethiopia	0.04	88	0.26%	55
74	Niger	0.04	82	-0.70%	71
74	Ghana	0.04	71	-0.71%	72
74	Kenya	0.04	76	-0.84%	73
74	Rwanda	0.04	81	-0.85%	74
74	Tanzania	0.04	91	-0.85%	75
74	Madagascar	0.04	80	-0.92%	76
74	Honduras	0.04	57	-1.01%	78
74	Cameroon	0.04	62	-1.02%	79
74	Cote d'Ivoire	0.04	59	-1.09%	80
74	Zimbabwe	0.04	58	-1.19%	81
74	Bolivia	0.04	53	-1.78%	88
74	Peru	0.04	36	-2.21%	90
87	Burundi	0.03	90	-1.56%	85
87	Zambia	0.03	69	-1.67%	86
87	Mali	0.03	77	-1.74%	87
87	Togo	0.03	72	-1.91%	89
91	Chad	0.02	64	-2.67%	91
92	Nicaragua	0.01	51	-3.10%	92
93	Nigeria	0.00	74	-3.55%	93

Appendix E

Efficiency Index based on initial per worker output in 1960, and average growth rates of per worker output from 1960 to 2000.

Rank - Efficiency	Country	Dynamic Efficiency	Rank - Real GDP	Avg. Growth	Rank - Growth
1	Hong Kong	1.00	47	5.67%	1
1	USA	1.00	3	1.91%	40
3	Ireland	0.99	23	4.10%	5
4	Republic of Korea	0.92	55	5.41%	2
5	Switzerland	0.81	1	0.98%	59
6	Japan	0.79	35	4.13%	4
7	Italy	0.76	15	2.98%	17
8	Belgium	0.74	12	2.61%	24
9	Austria	0.73	18	3.04%	16
10	Thailand	0.72	70	4.50%	3
11	Mauritius	0.70	42	3.88%	8
11	Spain	0.70	24	3.28%	12
13	Malaysia	0.68	43	3.82%	9
14	Portugal	0.67	32	3.48%	10
15	Finland	0.65	16	2.76%	20
16	Norway	0.64	10	2.39%	30
17	China	0.61	81	3.99%	6
17	Romania	0.61	76	3.91%	7
19	France	0.60	14	2.53%	26
19	Greece	0.60	27	3.13%	14
21	Israel	0.56	17	2.63%	23
22	Indonesia	0.50	69	3.34%	11
23	Pakistan	0.46	71	3.18%	13
24	Republic of Congo	0.42	86	3.08%	15
24	Syria	0.42	52	2.87%	19
26	New Zealand	0.41	2	0.61%	72
27	Gabon	0.40	45	2.74%	21
27	India	0.40	73	2.94%	18
29	Turkey	0.37	49	2.67%	22
30	Dominican Republic	0.35	46	2.57%	25
31	Denmark	0.34	8	1.88%	41
32	Brazil	0.32	37	2.42%	29
32	Egypt	0.32	51	2.51%	27
32	Netherlands	0.32	6	1.76%	43
35	Australia	0.27	5	1.68%	45
35	United Kingdom	0.27	11	1.91%	39
37	Canada	0.26	4	1.59%	47
37	Lesotho	0.26	82	2.44%	28
39	Morocco	0.25	54	2.31%	31
40	Sri Lanka	0.21	59	2.20%	32
41	Panama	0.19	39	2.07%	33
41	Sweden	0.19	9	1.69%	44
43	Chile	0.16	25	1.93%	38
44	Iran	0.15	31	1.94%	37
45	Trinidad &Tobago	0.14	22	1.82%	42
46	Malawi	0.13	88	1.98%	34
46	Nepal	0.13	80	1.98%	35
48	Bangladesh	0.12	61	1.95%	36
49	Argentina	0.08	13	0.79%	66
50	Mexico	0.07	21	1.54%	48
50	South Africa	0.07	20	1.09%	58
50	Uruguay	0.07	19	0.95%	61
53	Guatemala	0.06	36	1.45%	52
53	Jordan	0.06	33	1.53%	50
55	Colombia	0.05	34	0.83%	65
55	Costa Rica	0.05	26	0.68%	69

Data Source: Penn-World Tables versions 5.6 and 6.1

55	Ecuador	0.05	44	1.46%	51
55	El Salvador	0.05	28	0.72%	68
55	Guinea-Bissau	0.05	89	1.61%	46
55	Paraguay	0.05	38	0.88%	62
55	Philippines	0.05	50	1.16%	55
55	Zimbabwe	0.05	63	1.53%	49
63	Benin	0.04	75	0.66%	70
63	Burkina Faso	0.04	83	1.14%	56
63	Cameroon	0.04	57	0.39%	74
63	Cote d'Ivoire	0.04	62	1.16%	54
63	Ethiopia	0.04	85	0.74%	67
63	Gambia	0.04	78	1.11%	57
63	Ghana	0.04	72	0.85%	64
63	Guinea	0.04	53	0.65%	71
63	Honduras	0.04	48	0.44%	73
63	Jamaica	0.04	41	0.21%	77
63	Kenya	0.04	77	0.87%	63
63	Peru	0.04	29	0.00%	80
63	Tanzania	0.04	90	0.96%	60
63	Uganda	0.04	84	1.40%	53
63	Venezuela	0.04	7	-0.88%	87
78	Bolivia	0.03	40	0.01%	79
78	Burundi	0.03	87	0.27%	75
78	Rwanda	0.03	79	0.16%	78
78	Togo	0.03	74	0.26%	76
82	Chad	0.02	60	-0.43%	82
82	Madagascar	0.02	67	-0.60%	84
82	Mozambique	0.02	66	-0.50%	83
82	Senegal	0.02	56	-0.26%	81
82	Zambia	0.02	58	-0.61%	85
87	Mali	0.01	64	-0.77%	86
88	Niger	0.01	65	-1.03%	88
89	Nicaragua	0.00	30	-1.30%	90
89	Nigeria	0.00	68	-1.21%	89

Appendix F.

Dynamic efficiency Index based on initial per worker capital in 1980, and average growth rates of per worker output from 1980 to 2000. Productivity Index from 1990 results.

Country	Dynamic Efficiency	Rank - Efficiency	Rank - Capital	Rank - Growth	Rank - Productivity	Productivity Efficiency
Ireland	1.00	1	20	4	12	0.85
Norway	1.00	1	2	12	17	0.78
Republic of Korea	1.00	1	31	1	29	0.61
Hong Kong	0.94	4	26	3	1	1.00
Mauritius	0.85	5	45	2	4	0.97
Finland	0.74	6	3	11	21	0.73
Thailand	0.73	7	43	5	32	0.56
Switzerland	0.58	8	1	36	9	0.86
Belgium	0.55	9	4	21	9	0.86
Australia	0.54	10	5	23	15	0.82
Denmark	0.54	10	10	17	25	0.70
USA	0.53	12	12	18	1	1.00
Portugal	0.50	13	33	7	17	0.78
Japan	0.49	14	15	13	29	0.61
Austria	0.48	15	13	19	21	0.73
Canada	0.48	15	8	25	6	0.93
France	0.46	17	6	26	14	0.83
Sweden	0.45	18	9	27	19	0.76
Israel	0.43	19	17	20	13	0.84
Italy	0.43	19	14	24	7	0.88
United Kingdom	0.41	21	21	16	5	0.95
Chile	0.38	22	35	9	26	0.65
Netherlands	0.37	23	7	31	7	0.88
Dominican Republic	0.36	24	39	10	35	0.51
Turkey	0.35	25	36	14	33	0.55
Spain	0.34	26	19	28	15	0.82
Syria	0.29	27	25	29	26	0.65
New Zealand	0.27	28	11	32	24	0.71
Malawi	0.22	29	54	30	43	0.33
Greece	0.18	30	18	33	31	0.60
Morocco	0.11	31	44	34	9	0.86
Mexico	0.04	32	23	35	20	0.74
Argentina	0.02	33	28	41	26	0.65
Colombia	0.02	33	27	44	37	0.45
Ecuador	0.02	33	24	48	42	0.36
Guatemala	0.02	33	41	38	21	0.73
Honduras	0.02	33	38	45	38	0.41
Jamaica	0.02	33	40	40	34	0.52
Kenya	0.02	33	49	42	45	0.29
Madagascar	0.02	33	47	43	48	0.21
Panama	0.02	33	22	37	43	0.33
Philippines	0.02	33	42	39	36	0.47
Zimbabwe	0.02	33	37	47	47	0.23
Bolivia	0.01	44	34	52	38	0.41
Paraguay	0.01	44	52	49	1	1.00
Peru	0.01	44	32	53	40	0.40
Zambia	0.01	44	46	51	45	0.29
Nigeria	0.00	48	51	54	40	0.40

Data Source: Penn-World Tables versions 5.6 and 6.1, and Kumar and Russell (2002)

Appendix G.

Efficiency Indices based on variables as indicated in the column headings.

Data Source: Penn-World Tables versions 5.6 and 6.1

	Capital - 1980		Output - 1980		Output - 1960	
Country	Dynamic Efficiency	Rank - Efficiency	Dynamic Efficiency	Rank - Efficiency	Dynamic Efficiency	Rank - Efficiency
Ireland	1.00	1	1.00	1	0.99	3
Republic of Korea	1.00	1	1.00	1	0.92	4
Hong Kong	0.94	4	0.94	3	1.00	1
Switzerland	0.58	9	0.90	4	0.81	5
Mauritius	0.85	5	0.88	5	0.70	11
USA	0.53	13	0.56	6	1.00	1
Thailand	0.73	7	0.46	7	0.72	10
Netherlands	0.37	25	0.35	8	0.32	25
Belgium	0.55	10	0.31	9	0.74	8
Italy	0.43	20	0.26	10	0.76	7
Canada	0.48	16	0.24	11	0.26	28
Australia	0.54	11	0.21	12	0.27	26
France	0.46	18	0.20	13	0.60	16
Austria	0.48	16	0.18	14	0.73	9
Norway	1.00	1	0.18	14	0.64	15
Denmark	0.54	11	0.17	16	0.34	24
Sweden	0.45	19	0.16	17	0.19	30
New Zealand	0.27	31	0.15	18	0.41	21
Spain	0.34	28	0.15	18	0.70	11
Finland	0.74	6	0.14	20	0.65	14
Greece	0.18	33	0.13	21	0.60	16
Israel	0.43	20	0.13	21	0.56	18
United Kingdom	0.41	23	0.13	21	0.27	26
Argentina	0.02	36	0.10	24	0.08	36
Japan	0.49	15	0.10	24	0.79	6
Portugal	0.50	14	0.09	26	0.67	13
Mexico	0.04	35	0.08	27	0.07	37
Chile	0.38	24	0.07	28	0.16	32
Iran	0.32	29	0.07	28	0.15	33
Dominican Republic	0.36	26	0.06	30	0.35	23
Guatemala	0.02	36	0.06	30	0.06	38
Indonesia	0.62	8	0.06	30	0.50	19
Morocco	0.11	34	0.06	30	0.25	29
Panama	0.02	36	0.06	30	0.19	30
Syria	0.29	30	0.06	30	0.42	20
Turkey	0.35	27	0.06	30	0.37	22
Venezuela	0.02	36	0.06	30	0.04	44
Colombia	0.02	36	0.05	38	0.05	39
Ecuador	0.02	36	0.05	38	0.05	39
Jamaica	0.02	36	0.05	38	0.04	44
Malawi	0.22	32	0.05	38	0.13	34
Nepal	0.43	20	0.05	38	0.13	34
Paraguay	0.01	48	0.05	38	0.05	39
Philippines	0.02	36	0.05	38	0.05	39
Bolivia	0.01	48	0.04	45	0.03	50
Cote d'Ivoire	0.01	48	0.04	45	0.04	44
Honduras	0.02	36	0.04	45	0.04	44
Kenya	0.02	36	0.04	45	0.04	44
Madagascar	0.02	36	0.04	45	0.02	51
Peru	0.01	48	0.04	45	0.04	44
Zimbabwe	0.02	36	0.04	45	0.05	39