The Failure of Endogenous Growth

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Abstract: Fifteen years have passed since Paul Romer published his seminal paper that launched the field of endogenous growth. Today seems like an appropriate time to reflect back on this field and assess its contribution. My own assessment is that this line of research has not proven useful for understanding the most important question faced by economists today, namely, why isn't the whole world rich. Exogenous growth theory, in contrast, is. Endogenous growth may prove useful for understanding growth in world knowledge over time, but it is not useful for understanding why some countries are so poor relative to the United States today.

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Introduction

Over the last 15 years, the study of economic growth, rather than the study of business cycles, has dominated macroeconomics. Two developments, in particular, explain this phenomenon. The first is the seminal work of Paul Romer (1986) that launched the field of endogenous growth. The second is the construction of comprehensive data sets on international incomes using purchasing power parity adjusted prices by Robert Summers and Alan Heston (1991) and Angus Maddison (1995). On account of these data sets, economists now have a fairly complete picture of the differences in international incomes and their evolution through time.

In this article, I argue that endogenous growth theory is not particularly useful for understanding the evolution of the world income distribution despite the huge amount of effort expended. Instead, I argue that exogenous growth theory is much more useful for this purpose. In short, neoclassical growth theory, appropriately modified, accounts reasonably well for the pattern of economic development. Endogenous growth theory does not.

I plan to first set forth the reasons why endogenous growth theory fails as a theory of economic development, and then set forth the reasons why exogenous growth is successful in this sense. Towards this first goal, I divide endogenous growth models into two types. The first are models of imperfect competition. A common feature of these models is that they explicitly model research and development by profit maximizing firms. The second are models of perfect competition. A common feature of these models is that differences in policy or preferences translate into permanent differences in growth

rates. This is in contrast to exogenous growth models, where differences in policy or preferences translate into permanent differences in income levels, but not growth rates.

II. Endogenous Growth

A. Models of Imperfect Competition

A main branch of the endogenous growth literature consists of those papers that explicitly model the decisions of private agents to undertake costly research and development. These papers introduce imperfectly competitive elements to the models by conferring monopoly power to the successful innovator. Without the potential to earn monopoly profits, no self-interested agent would incur the costs to engaging in R&D activities. The pioneer papers in this literature are Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992). More recent efforts in this literature, for example Jones (1995), Segerstrom (1998), and Young (1998) are variations on these original papers intended to remove an undesirable prediction of these models, namely that countries with larger populations have higher growth rates and possibly higher levels of per capita output. The prediction known as the scale effect is not borne out by the data.[1]

Most economists agree that technological change is the source of sustained increases in per capita output. Most economists further agree that the creation of this knowledge is the result of research and development efforts undertaken by individuals and firms. The main reason the United States is so much richer today compared to 200 years ago is because of new inventions and discoveries made over this time. This branch of endogenous growth theory, therefore, has the potential to improve our understanding

[1] See Jones (1995) for a discussion of this data.

of how knowledge has grown and how the leading industrialized countries have been able to double their incomes approximately every 35 years over the last two centuries.

R&D models, however, do not help us understand why the whole world is not rich. Currently, there are huge differences in living standards between countries. The average person living in Myanmar or Burundi is reported to be close to 30 times poorer than the average person living in the United States. Myanmar and Burundi are not outliers in this respect. Figure 1 taken from Parente and Prescott (2000, p. 12) shows the distribution of per capita output relative to the U.S. level across countries in 1988. The countries included in the plot consist of all those with 1973 populations of at least one million and for which observations are available for all years over the 1960-88 period. As can be seen in Figure 1, there are about 25 countries in 1988 with relative incomes less than 6 percent the U.S. level. These cross-country income differences are much larger than the within-country income differences by most measures. For example, in 1988, the factor difference in the permanent income levels of individuals in the 90^{th} and 10^{th} percentiles in the United States was 4. For a similar comparison across countries, this factor difference was 20.

It is true that poor countries do not engage in R&D. However, they do not have to. There is a far less costly way for them to increase their per capita output. Poor countries need only adopt readily available technologies developed elsewhere in the world. This is, in fact, how the Japanese and South Koreans went from being relatively poor countries to relatively rich countries in the postwar period. It is also how the Chinese in the last decade have realized large increases in per capita output. The relevant question, then, is

why don't all poor countries adopt more productive readily available technologies? R&D models do not provide an answer to this question.

B. Models of Perfect Competition

Not all endogenous growth theory models R&D as the source of sustained economic growth. A large number of authors have constructed models whereby private agents do not undertake R&D and yet there is sustained growth. These models do not have to deviate from the assumption of perfectly competitive markets. These models tend to focus on the decision of agents to accumulate capital, where capital can be tangible or intangible in nature.[2] The key abstraction of these models for generating this result is that there are no diminishing returns to reproducible capital at the aggregate level. The pioneer works in this branch of the endogenous growth literature are Romer (1986), Lucas (1988), and Rebelo (1991). These models have the property that cross-country differences in policy or preferences lead to permanent differences in growth rates of per capita output.

Several of these models can be interpreted as models of technology adoption, since technology adoption in one way or another represents the accumulation of intangible capital. Nevertheless, these models are not useful theories of economic development. They are not useful because they fail to account for several key development facts. To establish this point, a brief review of the evolution of the world income distribution is warranted.[3]

[2] Intangible capital has been identified with human capital and organizational capital in the literature.

[3] Papers that have documented the evolution of the world income distribution over various periods of history are Jones (1997), Lucas (1998), Pritchet (1997) and Parente and Prescott (1993, 2000).

Evolution of International Income Differences

Huge differences in international incomes are a relatively recent phenomenon. For most of history, per capita income was constant and roughly equal across countries. Total output did increase, but at the same rate as the population so that living standards remained unchanged. A few societies, such as the Roman Empire and China in the thirteenth century did achieve increases in their per capita incomes above the world average. However, the per capita income of each society at their peaks was no more than twice the world average. Moreover, these differences were short-lived.

Significant differences in international incomes began to emerge in the first half of the nineteenth century when some countries began modern economic growth. Modern economic growth, that is sustained increases in per capita output, began first in England with the start of the Industrial Revolution. Shortly thereafter, it spread to continental Europe and the United States. For the next two centuries, per capita output in this small set of countries doubled every thirty-five years. In comparison, per capita output in most other parts of the world failed to increase until 1950. As a result of these different starting dates, differences in international income were already huge by 1950.

Given that two hundred years ago, differences in international income were tiny and given that by 1950 these differences were huge, it is obvious that growth rates differed across countries over this time period. This does not mean, however, that there are permanent differences in growth rates as this branch of the endogenous growth literature predicts. The evolution of the distribution of international income over the postwar period suggests that this is not the case.

If differences in growth rates were permanent, then income differences should have continued to widen over the postwar period. They did not. In fact as Table 1 shows, differences in living standards actually have diminished since 1972. Table 1 is taken from Parente and Prescott (2000, p. 19). It reports world mean income relative to the United States for various years over the postwar period. World mean income is a weighted-average of each country's per capita output where the weight is the country's population as a fraction of the world population.[4]

Table 1 reflects two important developments over the postwar period. First, subsequent to 1960, modern economic growth spread to almost every country in the world. The poor countries began to grow, and managed to keep pace with the rich countries. Second, a large number of countries out-performed the industrial leader, the United States, which continued to grow at its historical average rate in this period. As a result, world mean income relative to the United States increased after 1972.

The dramatic growth subsequent to 1978 in China, with 20 percent of the world's population, played an important role in this catching-up. Also contributing to this phenomenon are the dramatic growth experiences of a number of other countries in the postwar period. These include Japan, which increased its per capita income by a factor 5 between 1955 and 1980, Taiwan, which accomplished a similar feat between 1965 and 1990, and South Korea, whose performance was even more dramatic, increasing its per capita income by a factor 6.3 over the 1965-90 period. Such development experiences are miracles.

[4] Jones (1997) also documents this same pattern but in a different way.

It is important to note that all of these growth miracles are a recent phenomenon and are limited to countries that were far behind the industrial leader at the time the miracle began. No country at the top of the income distribution has ever gone on to quadruple its per capita output in a twenty-five year period. The leader has always taken at least eighty years to quadruple its per capita output. All of this suggests that the potential for rapid growth is greater the farther behind a country is from the industrial leader. Late entrants into modern economic growth have, in fact, typically doubled their per capita output in far less time compared to early entrants. Taiwan in 1965, for example, had the same per capita income as the United States in 1855. Whereas it took the United States forty-four years to double its per capita income, it took Taiwan a mere ten years to accomplish this same feat.

Figure 2 taken from Parente and Prescott (2000, p. 22) documents this general pattern. Figure 2 shows the number of years it took each country to go from 10 percent to 20 percent of the 1985 U.S. per capita output level against the year in which each country first achieved the 10 percent level. The 1985 U.S. level was $20,000 in 1990 prices. The difference in the length of the doubling period between the set of late and early entrants is dramatic. For early entrants, defined as those achieving the 10 percent level before 1950, the median length of the doubling period is 45 years. For late entrants, defined as those achieving 10 percent of the 1985 U.S. level after 1950, the median doubling period is 15 years. This pattern does not depend on the choice of starting level.

The Test of Theory

The main problem with this second type of endogenous growth theory is simple. It cannot explain the fact that development miracles are a recent phenomenon confined to poor countries, and it cannot explain the fact that later entrants to modern economic growth have been able to double their income in a far shorter period compared to early entrants. An endogenous growth model, such as Rebelo's Ak model (1991) predicts that a development miracle is just as likely to occur in the United States as it is in South Korea. All the United States needs to do to accomplish this feat is to adopt South Korean policy and institutions. This is highly implausible, as most people view current policy and institutions in the United States to be at least as good as South Korean ones. Moreover, the model predicts that a growth miracle is just as likely to have occurred in 1850 and 1950. These failures lead me to conclude that endogenous growth theory is not a reasonable theory of economic development.

III. Exogenous Growth Theory

Exogenous growth theory, in contrast, can account for the evolution of the world income distribution both prior to 1950 and after 1950. By exogenous growth theory, I do not mean the exact model of Solow (1957) with fixed savings rates or with optimal capital accumulation as solved out by Cass (1965) and Koopmans (1965). Solow (1957) recognized that his model was not a theory of international income differences. Instead, I refer to a modified version of that model that has evolved from the work of several

researchers over the last fifteen years. The Solow model with these modifications can account for the evolution of the world income distribution through time.

To understand the nature of these contributions, it is useful to describe the failure of Solow's original model. The main problem with Solow's original model in terms of accounting for international income differences and their evolution through time is that it fails to allow for a mechanism by which countries differ in the amount of technology they use. The reason for this is that Solow's original model completely abstracts from the technology adoption decision of agents. Technological change is exogenous and costless in the model, so firms need not do anything from one period to the next to realize an increase in productivity. All differences in international incomes are attributed to differences in savings rates, which may differ on account of preferences or tax codes.

The problem with this theory of international income differences is that savings rates do not differ systematically with the level of development. Table 2 taken from Parente and Prescott (2000, p.39) documents this fact. The averages for the set of industrialized countries, developing countries and Africa are taken from the *IMF International Financial Statistics Yearbook*. As the table shows, there is very little difference in the fraction of GDP invested by poor and rich countries. Savings rates cannot be the source of international income differences.

An important first step in eliminating these shortcomings is Parente and Prescott's (1994) model of technology adoption. Parente and Prescott start at the micro level and consider the decision of a firm to upgrade the technology of its plant. Technology adoption is costly. The amount of resources required to adopt a given technology depends on the policy of the country in which the firm is located, and on the

stock of useful knowledge in the world, which is assumed to grow exogenously. Parente and Prescott aggregate over firms and show that the equilibrium behavior of the economy is identical to that of the neoclassical growth model with two capital stocks and with differences in *Total Factor Productivity*. A country's *Total Factor Productivity*, which is a function of the country's policy and institutions, represents the fraction of the stock of world knowledge used by the country. Countries with more costly policy and institutions have lower *Total Factor Productivity* and use less of the available knowledge in the world. Parente and Prescott find that small differences in policy can have large effects on relative steady state income levels of the magnitude observed in the postwar period.

As a follow up to this work, Parente and Prescott (1999, 2000) attempt to determine the reason why policies that effectively constrain firm's technology choices are in place. They conclude based on an examination of historical and contemporary studies both at the industry level and aggregate level that the main reason such policies are in place is to protect specific groups with vested interests in the status quo from outside competition. These groups, primarily specialized factor suppliers to the current production process, have the state erect barriers to the adoption of better technologies. Parente and Prescott write down a model to show how these groups with the state's protection prevent the adoption of more productive technology and even lead to the inefficient use of existing technology.

The final step in eliminating the shortcomings of the Solow model is Hansen and Prescott (1999). Hansen and Prescott show how the neoclassical growth theory can be imbedded into a model with a Malthusian component to account for the different starting dates of modern economic growth. More specifically, Hansen and Prescott consider the

switch by an economy from a Malthusian production technology with land as a fixed factor, to a Solow production technology. As long as an economy specializes in the Malthusian production technology its per capita output remains constant. Modern economic growth begins only when the economy switches to the Solow production technology. The switch is made once the stock of useful knowledge reaches a critical level. This critical level is an increasing function of the barriers to technology adoption and capital accumulation in the country. Ngai (2000) has shown that this model is quantitatively consistent with the different starting dates of modern economic growth between the world's richest and poorest countries.

With these modifications, the Solow model can easily account for the evolution of the world income distribution through 1950. It can also easily account for its evolution after 1950. It can easily explain the existence of growth miracles. A growth miracle in the model corresponds to the transition by a country from a low steady state to a high steady state brought on by an improvement in policy or institutions. A necessary precondition for a growth miracle to occur is for a country to fail to exploit a large fraction of the available stock of knowledge in the world. If the barriers to the efficient use of this knowledge are removed in such a country, that country will experience a growth miracle. The currently rich countries do not meet this necessary precondition. By being rich they are using almost all the available useful knowledge. For the rich countries, growth is driven primarily by the growth of useable knowledge.

The model can also account for the fact that growth miracles are a recent phenomenon, and for the fact that later entrants to modern economic growth have been able to double their incomes in far shorter times than earlier entrants. The reasons are as

follows. Today, the stock of productive knowledge is a lot greater compared to one hundred years ago. Because this stock was not so large one hundred years ago, the gap in the amount of knowledge exploited by countries at the top and bottom of the income distribution was not so large. Consequently, a hundred years ago a growth miracle was impossible because there was not a huge amount of knowledge unexploited by countries at the bottom of the income distribution. Today, this gap is huge. Growth miracles are now possible because there is a huge amount of knowledge currently unexploited by countries at the bottom of the income distribution. Huge increases in per capita income in a very short period are attainable if a poor country reduces its barriers to the efficient use of this knowledge.

IV. Conclusion

Fifteen years have elapsed since Paul Romer published his seminal paper that launched the field of endogenous growth. It is time that we take stock of these efforts and assess their contribution. My own assessment is that this line of research has not proven very useful for understanding the most important question faced by economists, namely, why isn't the whole world rich. Exogenous growth theory, in contrast, is. Endogenous growth may prove useful for understanding the growth in world knowledge over time. I say may because the R&D models have not been rigorously taken to the data in the way the neoclassical growth model in its various forms has been, both in the context of economic growth and business cycles. Until this is done, we will not know if these models are truly useful or just another flash in the pan.

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Tables

Table 1. World Mean Income Relative to the United States: 1952–96

Year	Percent

1952	13.0
1962	13.3
1972	13.0
1982	13.8
1992	15.1
1996	17.7

Source: Maddison (1995); International Monetary Fund (1998)

Table 2: Fraction of GDP Invested: 1966–93

	Industrialized	Developing	Africa
1966	22.7	17.6	19.0
1970	23.7	17.5	22.9
1975	21.6	25.5	29.2
1980	23.2	25.5	28.0
1985	21.3	22.3	20.3
1990	21.5	24.3	19.6
1993	19.4	23.3	18.8

Source: International Monetary Fund (1994)

Figures

Figure 1

Distribution of Countries' Per Capita Income Relative to U.S.: 1988

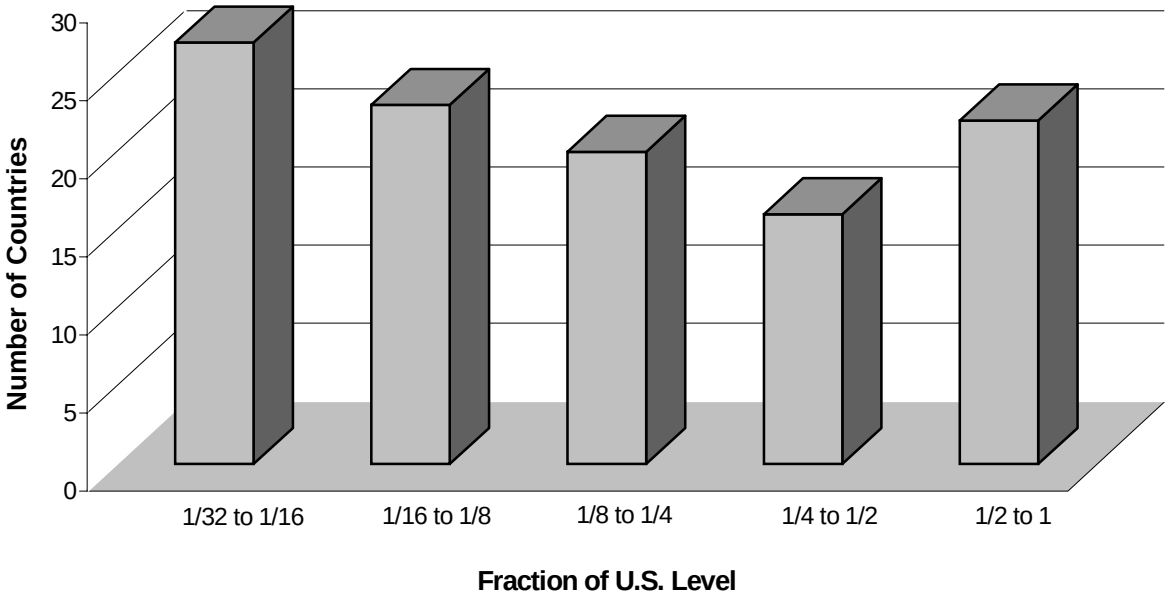

Figure 2

Years for Per Capita Income to Grow From 2,000 to 4,000 (1990 U.S. $)