Neoclassical Growth Theory for a Small Open Economy[1]

Michael Ellwood
07881 998649
michaeldavidellwood@yahoo.co.uk
www.economictheoriespro.com

Abstract

This paper is a continuation of the Neoclassical Growth Model (Solow Model) for a closed economy and builds up, through rigorous economic argument, a graphical model of growth in a small open economy as a solution to this unsolved problem. This graphical model is simple to use and easy to understand, once the foundations of the model have been worked through. Key assumptions in the mathematical models, namely the assumption governing the steady-state and the rate of convergence, are shown to be flawed. The model shows that open economies should grow more quickly, though not instantaneously, and implicates a different emphasis on policies for growth, based on the degree of openness of the economy.
Classification Number: F43

Introduction

This paper builds upon the neoclassical theory of growth (Solow Model) and as such sets this knowledge as a prerequisite to understanding the model that is to be developed. Indeed, the two main theories in growth economics, neoclassical and endogenous growth theory, are themselves not fundamentally different. Endogenous growth theory in essence describes a version of neoclassical growth theory with no diminishing returns. In the same way, whilst this model may look superficially very different from the theory in a closed economy, the differences are slight, yet make a crucial difference in explaining a very different growth dynamic in open economies.

[1] This paper was sent to H.M. Treasury in 2002 and I am very grateful to Richard Boxshall for his significant comments, especially considering that the university where I studied, University of St. Gallen, Switzerland, has always maintained that this work is of no importance, Oliver Haggenmuller also made a useful suggestion. I have received no financial assistance with this paper from any institution. Where no sources are shown all graphs are of my own design.

Why was this theory not developed long ago and in every economic textbook? There are two main reasons for this. Firstly, on a purely practical level, the majority of research in economics is carried out in the United States of America. Even with the present current account deficit brought on by “globalisation”, the United States is still best modelled as a closed economy and hence the direction of research was mainly guided by domestic conditions. Secondly, in terms of methodology, growth economics is one of the areas of economics which has been most taken over by mathematics. Indeed, attempts have been made to extend the neoclassical theory into international circumstances. These attempts are referred to in the paper generically as “mathematical models”. The fact that none of them have been recognised as providing a definitive solution to the problem highlights their limitations. The closed economy model has had its parameters altered and key assumptions have been thrown in with little economic reasoning. However, the theory and economic rationale have not been dealt with in any depth. This paper provides a remedy to this situation.

The paper is broken down into two main parts. The first part deals with the theoretical underpinnings and builds up the framework of the graphical model which explains the neoclassical growth theory for a small open economy. The most important chapters in the first part deal with contentious assumptions of the mathematical models, namely the level of the steady-state and the rate of convergence to the steady-state. However, as will be seen, the model works as a whole, with the economics of each part in itself coherent and reinforcing the other parts. The second part of this paper takes the graphical model as developed and introduces changes to the variables, in order to give a worked-through example of the main uses of the model as developed in the previous part. Additionally, an adjunct is included in part three before the conclusion in order to give my understanding of the conditions surrounding imperfectly open markets, as growth economists cannot form a consensus here either. Lastly, in the conclusion I try not to just summarise the model as developed in the paper, but to give some indication of the policy implications for governments seeking growth but having previously only worked with models of the closed economy.

Part I - The Foundations

The World - A Closed Economy

By the "world economy" I mean the addition of all individual countries' economies to form one single economy, which itself has no trade with any other economies. The world economy will therefore behave in the way as predicted by the Neoclassical Growth Model (the Model).

Underlying the Model is the production function which predicts a diminishing marginal product of capital, since the number of investment projects is limited to those within its own economy. However, it also predicts that capital is labour augmenting and so the marginal product of capital is always positive. These two features are represented in the graph featured in plate one.

This production function leads us to the Model as displayed graphically below in plate two and in particular to the curvature of the capital and output functions (due to the diminishing returns to capital).

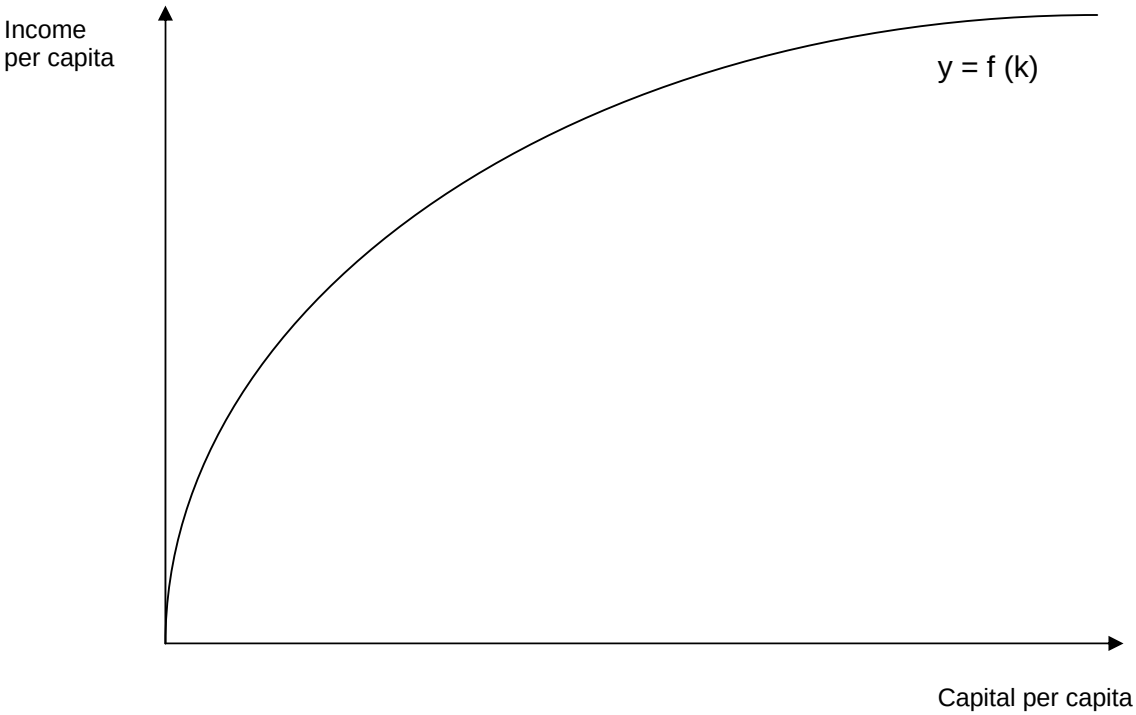
Due to the convenience of national income accounting for a closed economy, our understanding of the functions in a small open economy may become blurred, if we do not first define the functions for a closed economy. Of relevance are the capital function and the output function. For simplicity's sake we shall assume no government sector.

A closed economy has no foreign trade and can therefore have no foreign earnings. All income has to be earned through the production of goods and services. We can therefore equate output, income, and their components, as such:

1) Output = Income
2) Consumption + Investment = Consumption + Savings

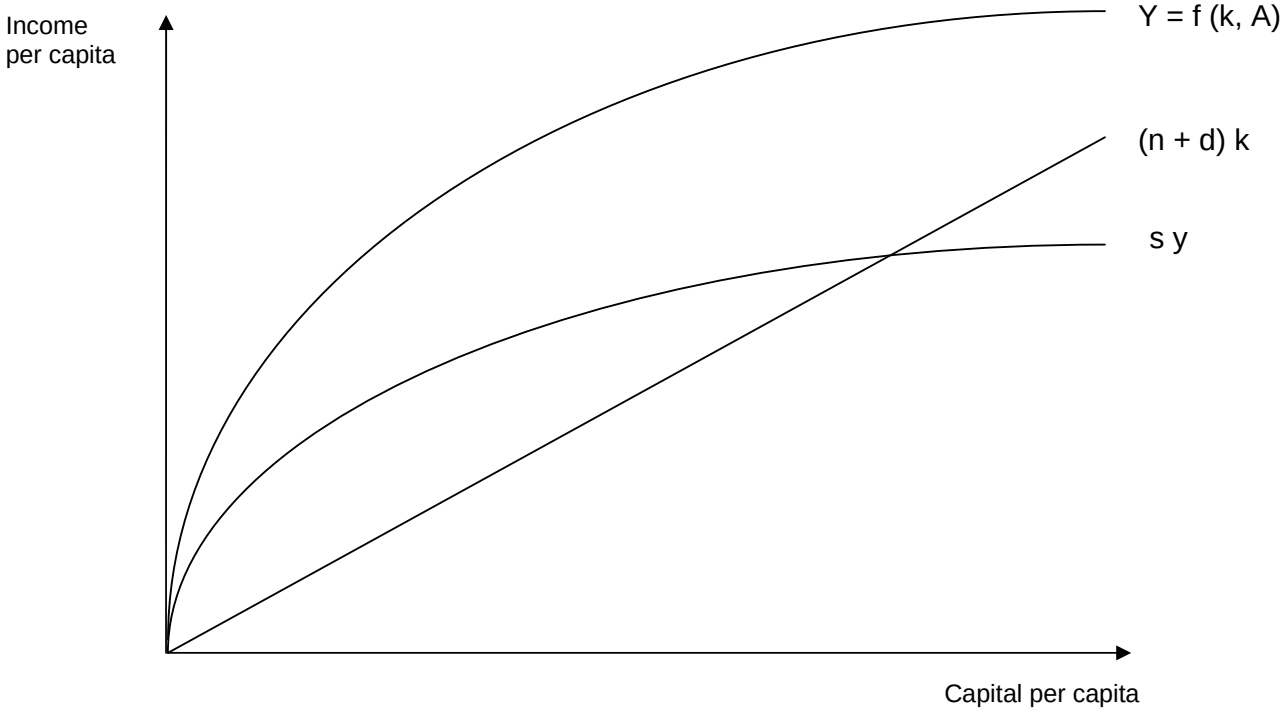
Since, in the Model for a closed economy, we have no chance of importing or exporting capital, our level of investment is always equal to our level of savings.

Plate 1 – The Diminishing Marginal Product of Capital



Source: Dornbusch,
Fischer, Startz, P. 54

Plate 2 – Neoclassical Growth Model for a Closed Economy



Source: Dornbusch,
Fischer, Startz, P. 56

That said we may conclude, by subtracting Consumption from both sides of 2), that Savings always equals Investment. Therefore, when talking of capital in the Model for a closed economy it is as well to think of investment or savings; a fact which will not hold true for the small open economy

The steady-state in the Model is an equilibrium position which the economy will tend to over time. The steady-state therefore indicates that level of income from which the economy displays no tendency to wander away from, ceteris paribus. It is defined as where investment is equal to the investment requirement, or in other words, where the capital stock shows no tendency to grow.

The investment requirement function is made up of the depreciation of the capital stock and the labour growth rate. It is self-evident that when capital needs to be replaced more frequently then that capital which would previously have been used to expand the capital stock is now merely being employed in replacing parts of the capital stock. This results in a smaller capital stock in the steady-state. Furthermore, in a closed economy, where capital is constrained to the level of savings, when there are more people and the same amount of capital each person has less capital, and so the marginal product of labour increases. This explains why the investment requirement function rotates anti-clockwise about the axis when either depreciation or the labour growth rate increases.

The effect of an exogenous technological change is that the same amount of capital is able to produce more output than was previously the case. This leads to an upward shift in the output function. As the output function is also our income function, we are able to say that income rises by the same multiple as output rose. Since saving is a fixed proportion of income, a higher level of income leads in the next period to a higher level of savings. The savings function, the output function and the income function hence all shift upwards, leading to a higher steady-state level of output and income.

I shall now leave the Model for a closed economy, after only this basic analysis, since it is very well known. It shall, however, periodically become necessary, during the

analysis of the small open economy, to refer back to the Model for a closed economy as it is laid out here.

The Consequence of Capital Mobility and Population Growth

Capital mobility is given when there are no exchange controls, exchange rates are free to trade at their market value, perfect information is given and there are no transaction costs. The Model for a closed economy restricts the level of investment to the level of savings. Therefore, when the population growth rate increases, these new additions to the population have to be equipped with investment goods, so that they can be productive. From a technical point of view, the marginal product of capital given to new entrants to the economy will be a lot higher since they have absolutely less capital. This leads to a transfer of capital to the new entrants. This process will come to rest when the marginal product of capital is the same for all members of the economy. It can therefore be seen that each individual has absolutely less capital, since the same amount of capital is spread more thinly over a larger number of people. Since each person has less capital, it stands to reason that each person will produce less output, meaning his savings from income will also be reduced, as will generally be his consumption, though this depends on the positioning on the capital function, in accordance with the golden rule of consumption.

Perfect capital mobility, however, means that investment will flow to where it can be used most efficiently. This means that each new individual added to the small open economy will immediately be equipped with the same amount of investment goods as existing members of that economy, assuming his marginal product is the same. Due to the negligible size of our small open economy this population growth will have no effect on world population growth. We can henceforth say that the level of capital allocated to new entrants will equal that of existing persons, since investment will flow in from abroad. Therefore, on a per capita basis, we are able to say that the level of investment remains unchanged.

However, an increase in the population growth rate is not completely without consequence on an individual basis. This is because new entrants will be equipped with new investment goods, which have not yet faced any rate of depreciation. This

newer investment acts to reduce the average age of investment goods, whereupon we will experience a shift back along the investment function, as if the economy were going back in time. This shall be illustrated when we look at the investment and output functions.

The Allocation of Capital between Countries

The total sum of capital, as meant either as world investment or world savings, which is available to be allocated to individual constituent economies is determined by the Model for the closed economy, as discussed previously. This can also be represented by the addition of each country's individual investment and savings functions. The interaction of the world savings and the world investment functions brings about the world interest rate. This is the rate at which each country will lend or borrow capital to finance investment projects.

Yet capital will not necessarily be divided between countries, not even on a per capita basis, equally, even given the inherent assumptions of perfect information, no transaction costs and completely flexible exchange regimes in all constituent countries. The division of capital will instead depend on the state of technological advancement and the depreciation rate. As we shall see later to effect, the division of capital, in per capita terms, is independent of the level of savings and the rate of population growth for the reasons given in the previous section.

The state of technological advancement can best be represented by the marginal efficiency of investment functions for each individual country, since we assume in the Model that technological advances lead to more efficient production. More efficient production leads to higher returns on investment. These returns on investment will be discounted by investors wishing to invest their savings. Investors will consider two factors whilst discounting the return of an investment project. Firstly, the project should cover the opportunity cost of saving during the period of the investment project, i.e. the world interest rate. Secondly, the investment project should yield more than will have to be written off on it during the course of the project.

Plate 3 – The Allocation of Investment

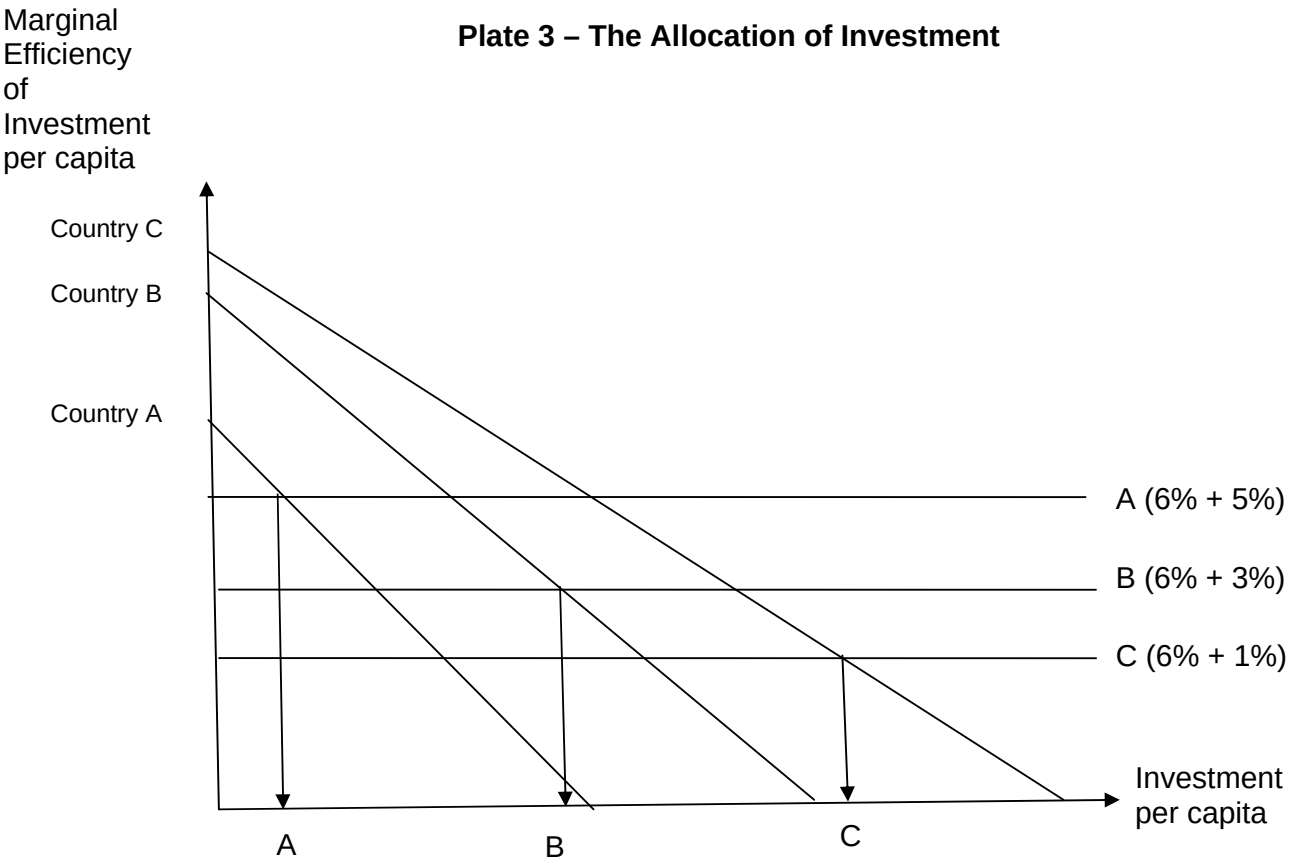
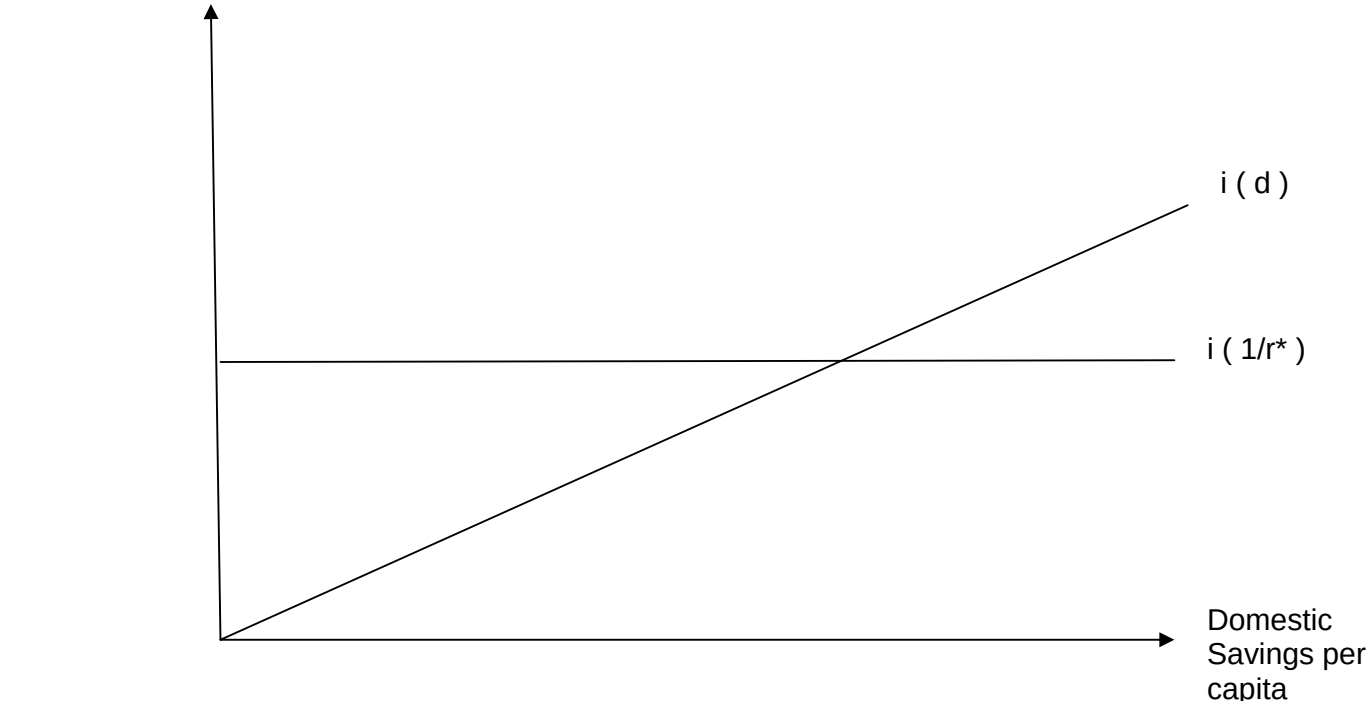


Plate 4 – The Investment Function



These two factors can be grouped together in what has been called the "discount rate" by Frank Ramsey.[2]

This leads to the figure in plate three which represents the marginal efficiency of capital in three countries with differing levels of technology and depreciation rates. We assume a world interest rate of 6%, the first percentage in brackets, the second being the depreciation rate. (It is easier to work from the start with per capita values instead of allowing a mixture of aggregate and per capita graphs to cause confusion).

It can be seen from the differing marginal efficiency of investment functions, which are due to differing levels of technology, and from the differing rates of depreciation that we end up with unequal levels of investment per capita. The interest rate however, being the world interest rate, is for all countries at all times equal. A change in the world interest rate therefore leads to both absolute and relative changes in the level of investment per capita depending on the elasticity and positioning of the marginal efficiency of investment per capita function of each country.

The Investment and Output Functions

From the assessment of the allocation of capital we may now consider how the investment function for a small open economy would look, and by implication therefore also the output function. As investment in a small open economy it is to be understood all goods which are employed within the small open economy in the production of other goods, regardless of ownership. The assumption of perfect capital mobility is naturally also given.

In this world of perfect capital mobility, wherever the return on an investment project exceeds the world interest rate then savings will flow into this project, so long as the excess return is not exceeded by the rate of depreciation. This means that the national interest rate is equal to the world interest rate, r*, which is at all times equal to the marginal product of capital. If we now translate this thinking into the form of the

[2] Ramsey

Model, then we arrive at the investment and investment requirement functions shown in the figure in plate four.

The investment function should be understood as being independent of domestic savings and inversely proportional to the world interest rate. As shown in the previous section, the level of technology, the marginal efficiency of investment, affects the amount of investment, i.e. the height of the investment function. The rate of depreciation, which is constant over time, determines the equilibrium position, where the amount of investment equals the level of depreciation. The graph therefore demonstrates that investment is independent of domestic savings; is inversely proportional to the world interest rate and depreciates at a constant rate over time. That the function is horizontal shows that the level of investment in our economy is marginal compared to the amount of capital in the world and that there are no barriers to capital flowing in, all meaning that we are not at all reliant upon our domestic savings. Since investment per capita is constant for a given level of technology, ceteris paribus, the economy experiences no diminishing marginal efficiency of investment. If, for example, the economy finds itself with less investment than it should be allocated (according to the factors in the above section) then the marginal efficiency of this investment would rise, in the closed economy. In the open economy, however, it merely imports capital for investment, meaning that the marginal efficiency of investment remains unchanged. With more investment than should be allocated to it (again according to the factors referred to in the above section) the marginal efficiency of investment would sink, as happens in the closed economy. In the small open economy this less productive investment would be transferred to more productive countries; a capital export. All this means to say is that, analogue to the section, we have a certain allocation of investment per capita, which, given that we are in a world steady-state and ceteris paribus, will be constant over time, completely independent of domestic savings; a flattened out investment function.

As world capital grows over time the investment function will shift with diminishing intensity upwards, reflecting the diminishing product of world capital. This is since more capital in the world economy, ceteris paribus, leads to a lower world interest rate, yet the world as a whole experiences a diminishing marginal product of capital.

That the world interest rate has not fallen over the centuries most probably reflects continuing industrialisation throughout the world and barriers to perfect capital mobility, e.g. political risks and wars.

Since the level of investment per capita remains constant, so too does the level of output per capita, since it is realistic to assume that output is merely a function of investment. This results in the output function being another straight line, as shown in plate five.

As discussed in “The Consequence of Capital Mobility and Population Growth”, an increase in the population growth rate, whilst leaving the per capita level of investment and output constant, leads to the average age of investment goods being reduced. This is equivalent to a movement leftwards along the investment function, as if we were going back in time. I see no reason why this should not also hold for human capital, since more relevant and newer skills will be obtained by immigration with a lower average age than the population at large. Immigration will also lead to the same effect if no investment goods are brought with the immigrant, though if they are it will depend on the amount of depreciation of these relative to the average amount of depreciation of those already in the economy and could lead to a move in the opposite direction, as is also the case with human capital. A rise in the population growth rate will not affect the marginal efficiency of investment per capita function since it is the basis of neoclassical growth models to assume that all new entrants to the economy resulting from population growth acquire the same skills. This is unlikely to be the case with immigrants and so their arrival will undoubtedly cause a shift in the marginal efficiency of investment per capita function, at least in the short term. This means that they will bring about a shift, either upwards or downwards, in the investment per capita function.

The predictions for the investment and output functions are generally accepted[3] and will form the basis of the analysis for changes to the level of domestic technology, which we shall come to in the next part.

[3] Barro et al

Plate 5 – Investment and Output

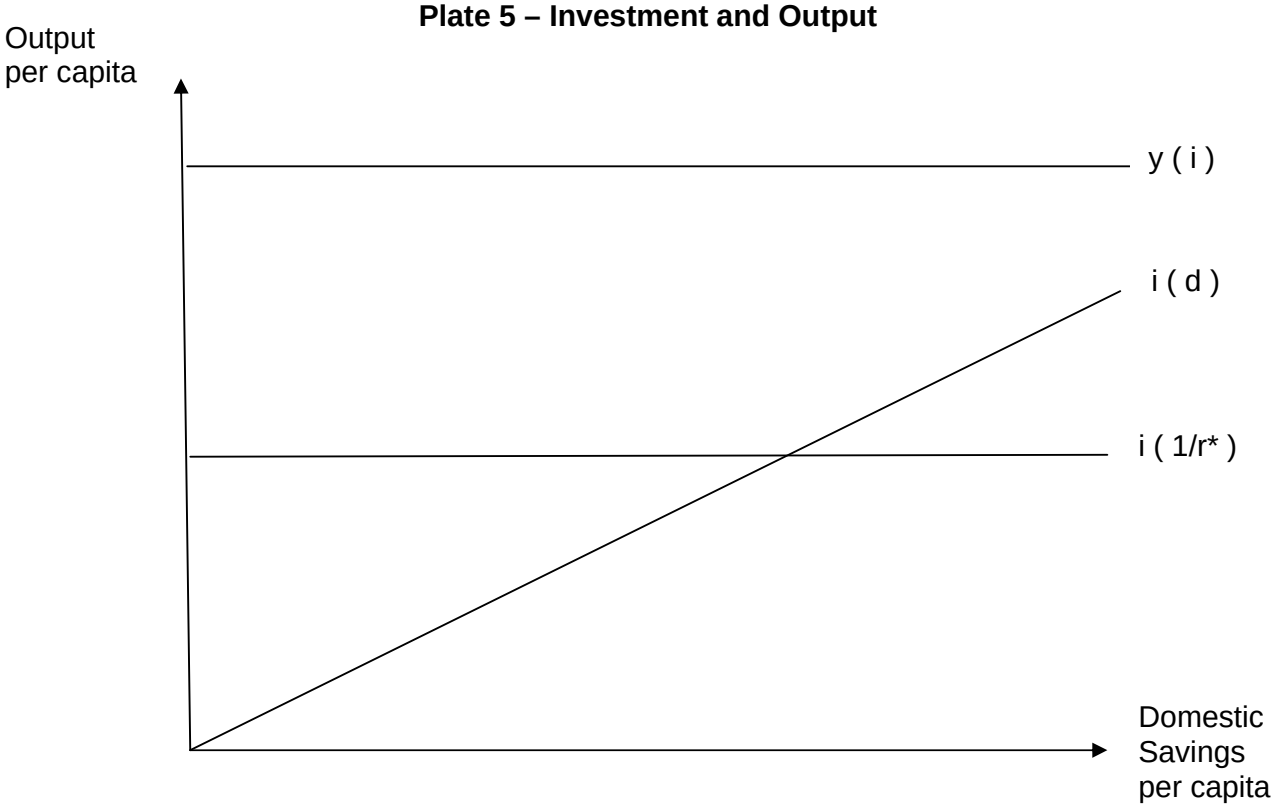
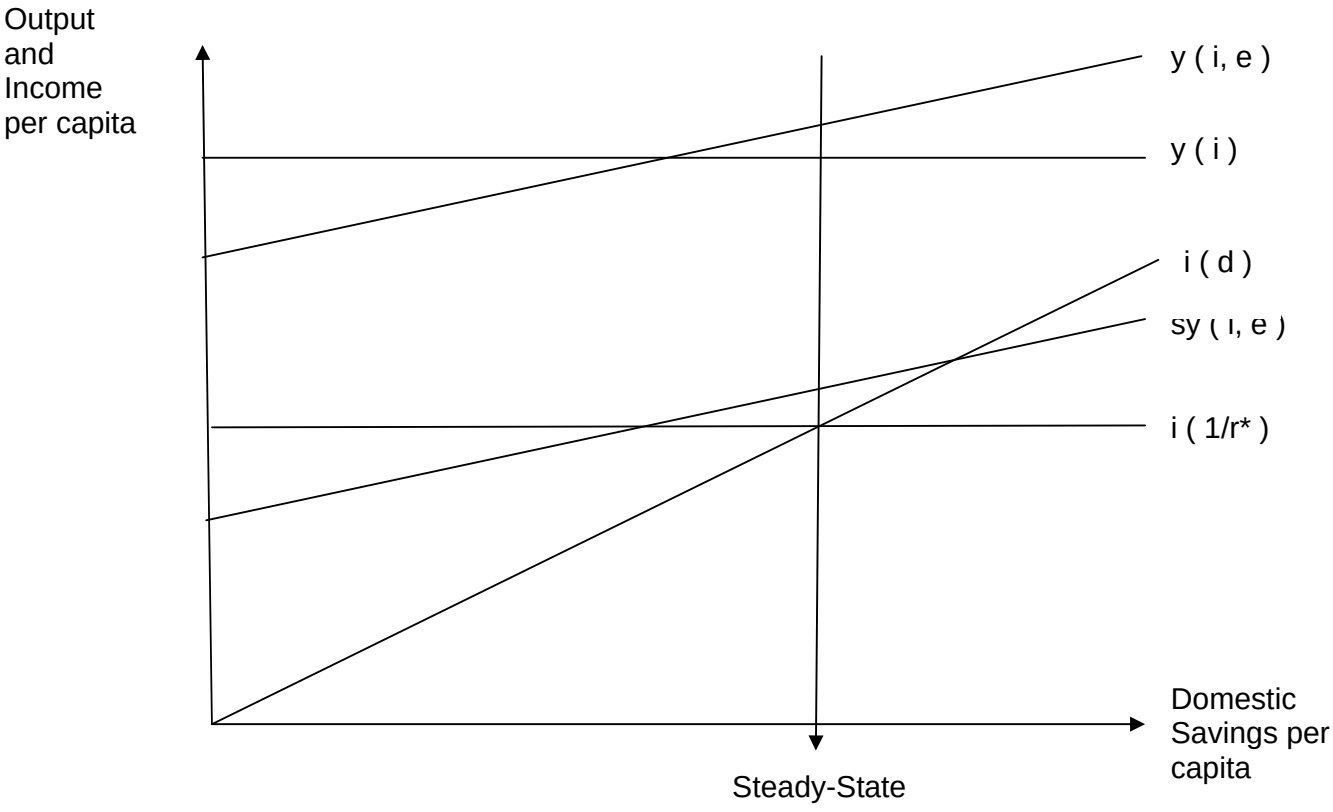


Plate 6 – The Model for a Small Open Economy



The Real Steady-State

I shall define the steady-state as being that level of capital stock at which the small open economy will settle at and from which there will be no tendency for it to grow, ceteris paribus. Since output is merely a multiple of investment then we may also say that output will show no tendency to grow. Nonetheless we should concentrate on the capital stock. From the graph in the plate five it should be easy to recognise that the capital stock is being added to where the investment function exceeds the investment requirement function, and is shrinking where the investment requirement function exceeds the investment function, just as in the Model for a closed economy. Therefore the steady-state is where the investment function equals the investment requirement function.

The definition which is used in mathematical versions of the Model for a small open economy defines the steady-state as being where the current account is equal to nil.[4] The reasoning behind this is that at this point the economy is able to finance all its own investment with domestic savings. It should therefore be pointed out that the steady-state is merely a level of investment. The same models espouse that investment is independent of domestic savings. Yet were domestic savings to rise, then this would mean, according to this definition, that this level of investment would be reached earlier, since investment would equal savings sooner, meaning the capital account will be balanced sooner, and thus also the current account. In other words, domestic savings can influence the level of investment. This also implies that the ownership of the capital stock is relevant as to whether it displays any tendency to grow or not. It also comes to the conclusion that a country with a higher level of technology cannot for eternity finance a higher level of output by importing capital. This last commonsense objection should be superfluous in the face of the theoretical criticism.

From previous sections it should be clear that the rate of depreciation is still to be considered as part of the investment requirement function, yet population growth is not, on a per capita basis. Population growth affects merely the dynamics leading to the steady-state, not the steady-state itself.

[4] See Carlberg for a typical example.

The interaction of the investment function with the investment requirement function leads not just to a steady-state level of output, but also to a steady-state level of income. This is important, since otherwise if all countries were to find themselves in the steady-state, then, under the current account nil definition, this would mean that there would be no flows of capital. The economies with higher levels of technology would have to invest entirely their own savings, instead of merely importing capital from where the marginal product of investment is less. Allowing for differing steady-state levels of output and income means that everyone's steady-state is not achieved when each country behaves as if it were a closed economy.

Lastly, the new definition describes the advantages of capital mobility much better, saying that the steady-state will not be constrained by domestic savings or by a higher population growth rate, but rather by competitive advantages and the macroeconomic environment. Therefore I would hope that my definition of the steady-state is much more compatible with the postulates of international macroeconomics.

The Savings and Income Functions

Since the small open economy arrives immediately at the required level of output, then we are able to say that savings may also jump to a certain level, not having to start from nothing as in the closed economy. It is however important to point out that people will save a constant proportion of income and not output. We can therefore say that the savings and income functions will move in tandem and the investment and output functions likewise.

We are able to define income as being output minus the current account deficit, thus giving the sum of money earned by domestic residents of the small open economy. Since we assume that the small open economy has flexible exchange rates (in order for perfect capital mobility to exist) we are able to say that a current account deficit has to be balanced out by a capital account surplus and vice-versus. The capital account surplus is where the level of domestic savings is exceeded by the level of

investment, or, in other words, where we have to import savings to finance our investment projects. The reverse applies for the capital account deficit.

In the Model for a closed economy, the investment function, and thus also the savings function, experiences diminishing returns. This is since the number of investment projects in the economy is limited. Naturally the most profitable projects will be carried out first of all, leading at first to an above average growth of income and savings. Thereafter the returns tail off and the curve flattens out, meaning that capital, in the closed economy, is subject to the law of diminishing marginal utility.

The case of the small open economy is however quite different. The relatively small amount of domestic savings, when compared to the size of the world economy, face what can be termed as an unlimited number of investment projects. Therefore savings in the small open economy experience no diminishing product, since an infinite amount can be invested at the same rate abroad. The income and savings functions therefore rise at a constant gradient and never flatten out.

This reasoning allows us to build upon our graph with the addition of these two functions, as shown in plate six. It should be noted that the functions are parallel, since the balance of payments is always balanced, due to perfect capital mobility.

The Consumption Function

In order to look at the consumption function it is necessary to return once again to national income accounting. Most importantly for the small open economy is that income is no longer equal to output. Otherwise the components of income and output remain the same, i.e.:

1) Income =/= Output
2) C + S =/= C + I
3) S =/= I

Consumption is always constant, either the gap between investment and output or savings and income.

If at first the function appears to be incredible, I would recommend looking at the savings and investment functions and following through what happens with the balance of payments. Many people start by looking at income, yet it is principally the ability to finance expenditure, i.e. the capital account, which is important, and not the symptom, the current account. Lastly, it should be remembered that any level of domestic savings exceeding the level of investment allocated to our economy will very quickly find investment projects abroad, meaning a capital account deficit will quickly arise.

Part II – The Model at Work

In the second part of this essay we shall examine how the Model for a small open economy, as developed in the first part, reacts to changes in the variables. I hope that by seeing how this Model reacts the validity of it, due to its sensible predictions, will be recognised.

An Increase in the Interest Rate

An increase in the world interest rate, which is always equal to the domestic interest rate, can only result from there being less capital in the world or more investment projects. This means that the allocation of investment to each country will also decrease according to the positioning and elasticity of its marginal efficiency of investment function, ceteris paribus. The supply of capital in the world is, as discussed in part one, determined by the Model for a closed economy. Since this has already been discussed we shall leave the causes of the drop in the level of capital to one side and merely accept that the interest rate has risen.

If we first assume that the small open economy is in the steady-state, and then that an increase in interest rates brings it to a new steady-state, as shown in plate seven.

Plate 7 – An Increase in the Interest Rate

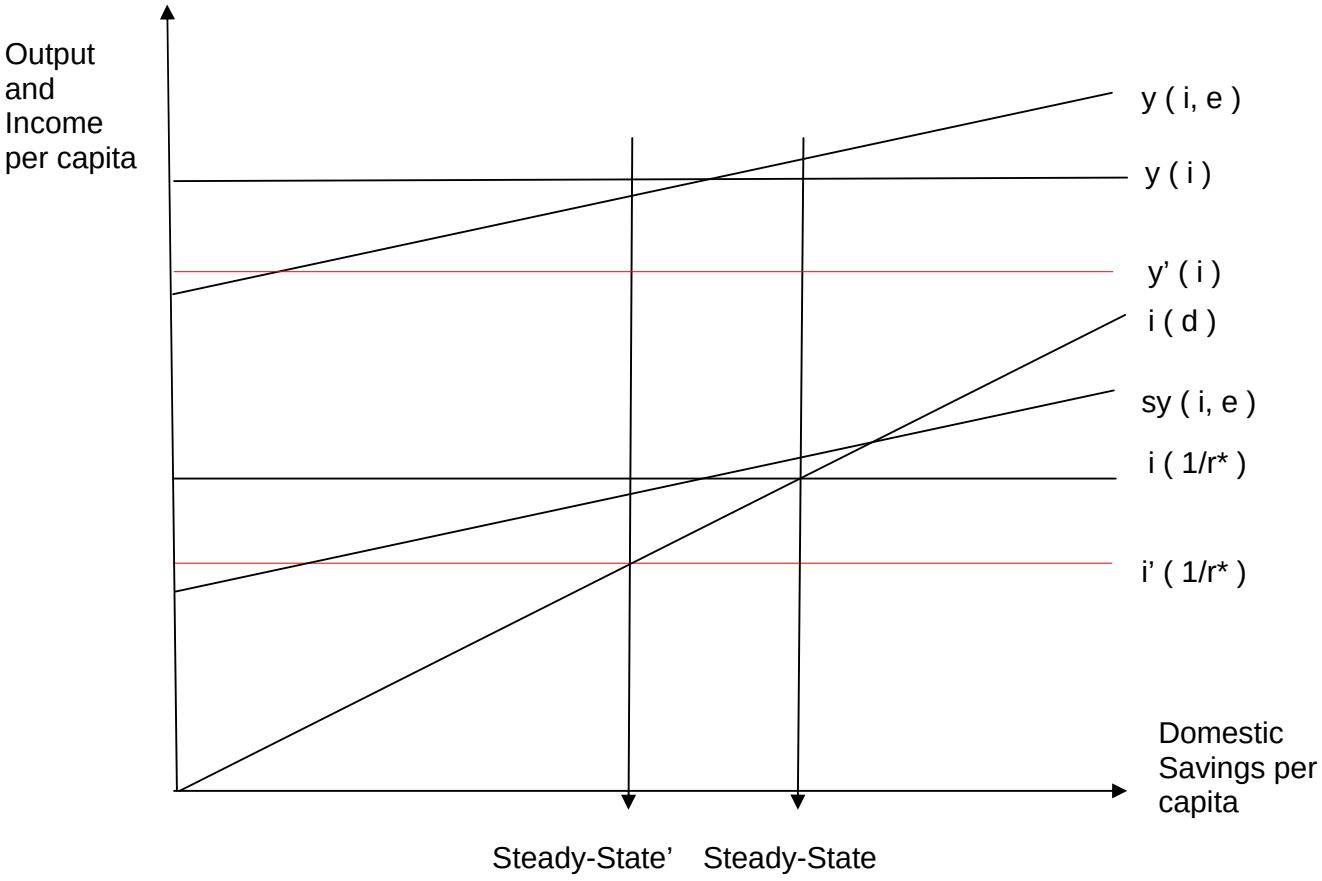
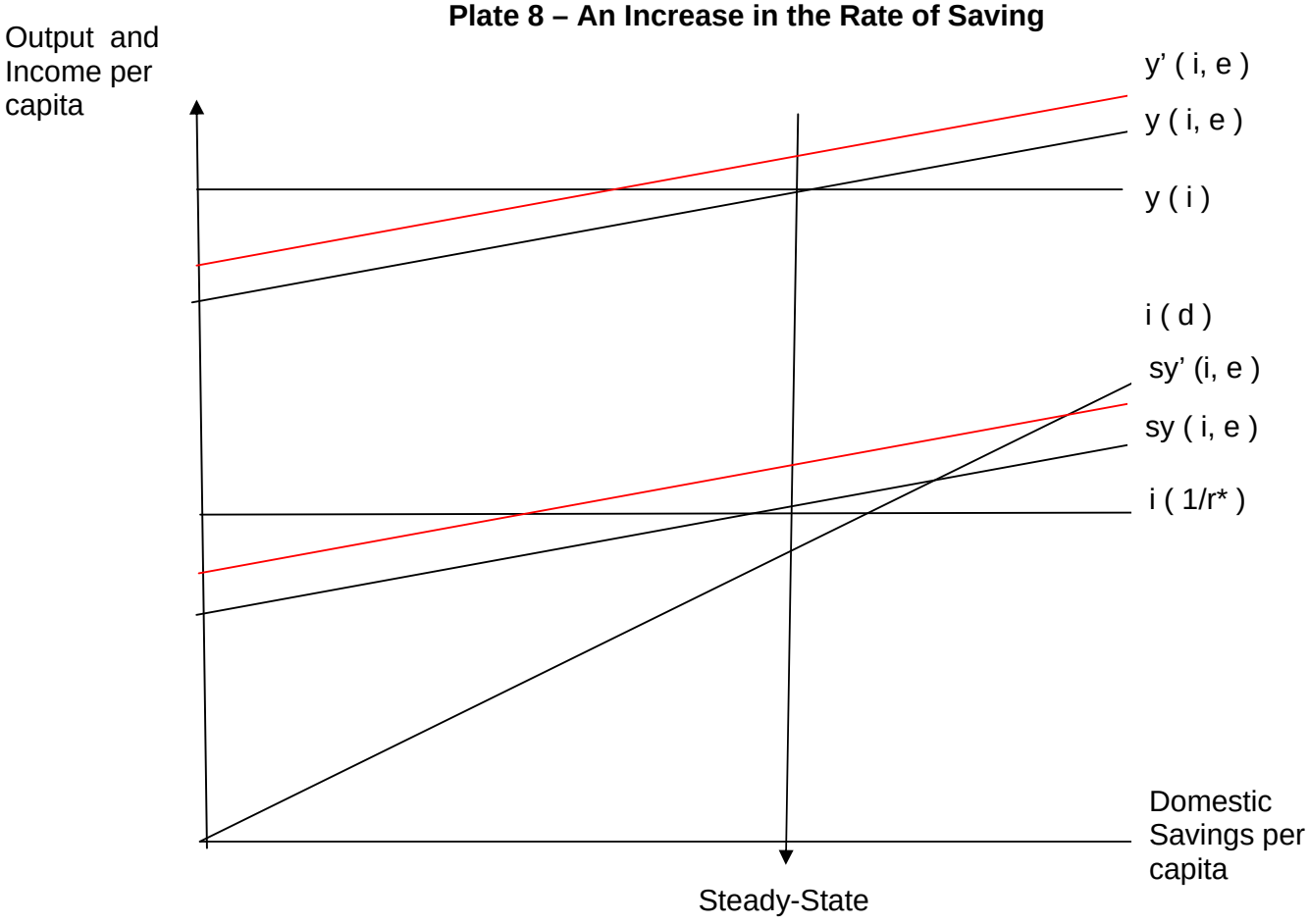


Plate 8 – An Increase in the Rate of Saving



What is important to realise is that the allocation of investment between countries is still carried out on the same basis according to the marginal efficiency of investment. The higher interest rates merely lead to absolutely less investment being carried out at home and abroad.

The downward shift in the investment function is easy to follow, since the interest rate determines the level of investment. This also leads to a parallel shift downwards of the output function, since output is a function of investment. The savings function is a function of income. There is no way for the small open economy to specify if it wants its savings invested at home or abroad, meaning that we can assume that the savings are evenly dispersed throughout the world. Let us imagine that we have our savings invested in five different economies, plus our own. If one of these economies now stops saving altogether (not our own economy) then part of our savings which we have invested in the other economies will flow to provide investment in the economy now saving nothing. Not all of the investment projects which were previously being financed will now be financed, and some of the investment projects in the other countries which we previously invested in will now be neglected, since the marginal product of investment in the non-saving country is higher, and there are absolutely fewer savings in the world . We can hence say that the proportion of world savings made up by our small open economy's savings has risen. The absolute amount of our savings remains the same though, meaning that the income function remains the same. (If we imagine the four other economies are such as our own, only much bigger, then the addition of all the reductions in investment in these, plus the reduction in our own economy, will be equal to the amount of investment allocated to the non-saving country, the sixth economy). We will however see a move along the functions, since we will arrive at a lower steady-state level of income per capita. Exactly how much of our savings are invested at home and abroad will depend on the gradient of the savings and investment requirement functions in our economy as well as the marginal efficiency of investment functions in countries around the world.

Finally, the increase in interest rates will mean that as a debtor we will have to borrow more capital to cover the cost of the investment projects and the increased interest payments. The reverse is true for a creditor. This means that there is an increase in the size of the capital account surplus/deficit, leading to the same increase in the

current account deficit/surplus. This occurs because at a higher interest rates the returns on savings (the gradient of the savings function) increases. This would be represented in the graph by a rotation of the savings and income functions. That said, I would however assume that this effect would be by far outweighed by the reduction in investment.

An Increase in Savings

An increase in savings will, in contrast to the Model for a closed economy, lead to no change in the level of investment, in the small open economy. Neither will it have any effect on a specific level of investment i.e. the steady-state. Yet there is always an incentive to save money, since there is for our small open economy an unlimited number of investment projects abroad. So although an increase in the level of savings does not make us arrive at the steady-state any sooner, it does however raise our level of income in the steady-state, as shown in plate eight.

As a note to savings, we may say that where a country is forced to consume a large part of its output, due to, for example a low level of technology (and thus a low level of output) and high costs of living (for example due to geographical conditions), we can imagine a situation in which, from the outset, there are no savings, meaning income will be permanently low, even where the steady-state is reached.

An Exogenous Technological Change

The Model is often criticised since the main determinate of growth, technology, is an exogenous variable. Yet it is not the role of economics to try to relate circumstances with no theoretical relationship with empirics given as the only validation. To criticise the Model because it describes causes of growth which cannot be expressed in a formula, is to oversimplify the subject and displace it from its position as a social science to that of a pure science, no doubt to the wishes of many in the field but unfortunately contrary to the subject matter at hand. On this basis the business cycle will also draw criticism, due to it, for the most part, being based on “animal spirits”.

Plate 9 – An Exogenous Technological Change

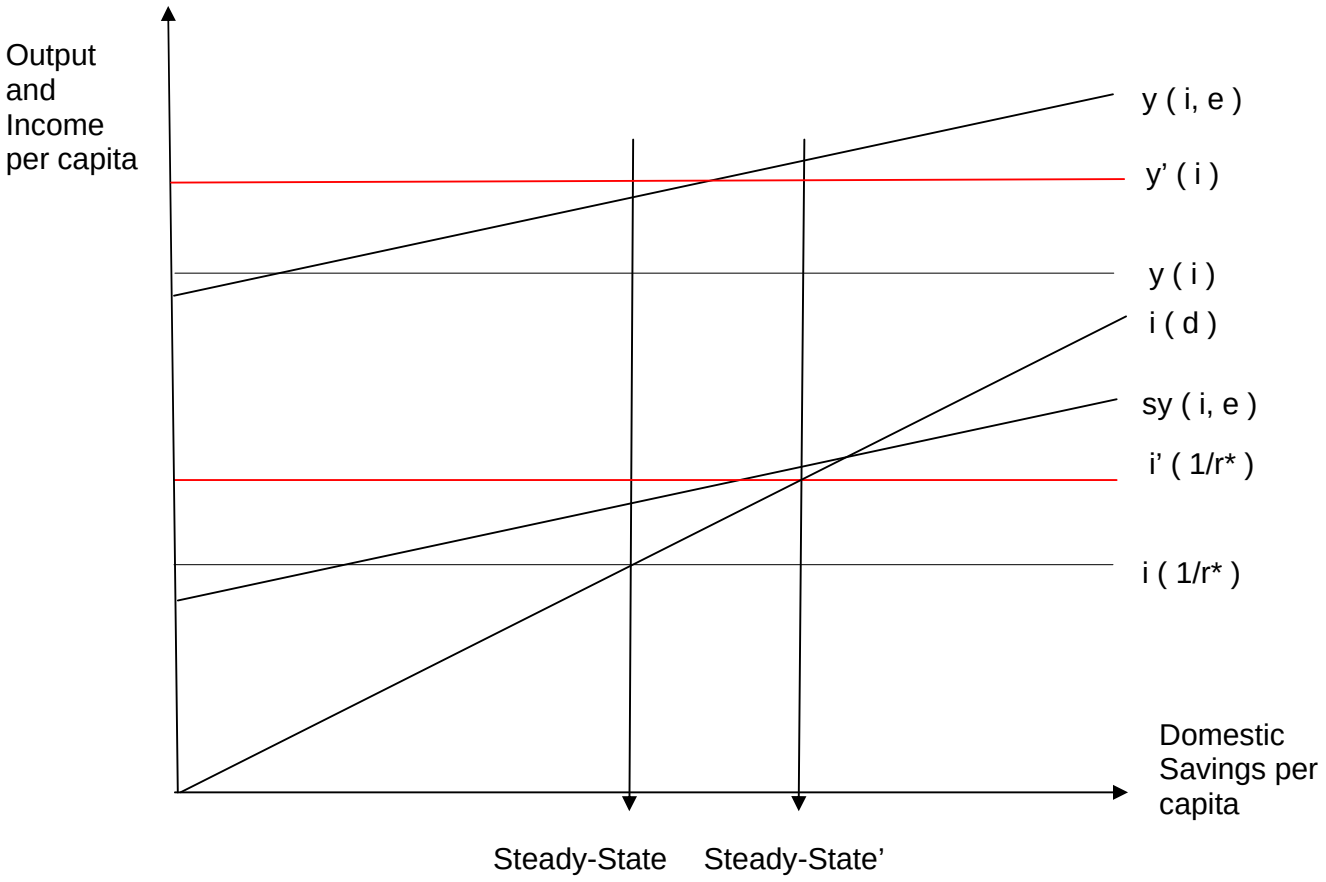


Plate 10 – An Increase in the Depreciation Rate

We can assess the effects of an exogenous technological change in the production process of domestic output, as illustrated in plate nine.

The development of the small open economy will thus be much more reliant on foreign capital for a much longer time with the higher level of technology and investment. We will see an absolutely higher level of savings and income due to the higher steady-state. The size of the capital and current accounts will of course depend on the gradient of the savings function and the investment requirement function.

Technology is difficult to contain in a small open economy due to the trade in goods and services. Most realistically we can assume that our technology will gradually seep into foreign markets, raising the returns on our savings and thus our income. We will therefore see a lagged upward shift of our savings and income functions. Once our innovation has been fully incorporated into foreign production processes then the upward shift in the income and savings functions will be equal to that of the output and investment functions. This means that we will have a higher steady-state and yet the relative allocation of investment will have remained broadly the same as before the innovation, though how the innovation will affect marginal efficiency of investment functions around the world may vary significantly.

An Increase in the Depreciation Rate

We can first note that the investment requirement function, now comprising only the depreciation rate, will for this reason be a lot less steep than in the closed economy. This is compatible with real world observations where growth in closed economies is a lot more sluggish and seems to be more restrained than that of open economies.

That said, the depreciation rate works in exactly the same way as in the closed economy. The reasoning is laid out in the section on the allocation of capital and so shall only be dealt with very briefly here. In contrast to a technological improvement, a higher depreciation rate means that there are fewer investment goods which over the course of their lifetime will yield more than the “discount rate”. Naturally the most profitable investment goods will be bought first. The point where the returns on the

less profitable investment goods is exceeded by the discount rate is therefore, with a higher depreciation rate, arrived at much sooner, meaning that the steady-state is arrived at much sooner. This is shown in the graph in plate ten by an anti-clockwise rotation of the investment requirement function, just as in the closed economy:

An Increase in the Population Growth Rate

As discussed in the section “The Consequences of Capital Mobility and Population Growth”, population growth leads to no shifts or rotations in our graph, yet it still has an effect on the per capita values. This is since new workers in our economy will receive new investment goods, thereby lowering the average amount of depreciation on investment goods on a per capita basis. This is shown in the graph in plate eleven, in which the arrow indicates a movement along the investment function away from the steady-state.

Part III-Imperfect Capital Mobility

I shall finish this essay by giving a brief outline of this further line of enquiry and sketching out a rough graph for this situation. It will become clear that this situation has not been looked into in as much depth. Nevertheless I feel that the analysis laid out here makes a valuable start in the right direction.

We shall consider a half-way position between the small open economy and the closed economy, this being the half-open, small economy. In this analysis we shall assume that the small open economy cannot affect the world interest rate and that it may only import / export half of the capital which the small open economy was able to.

An Increase in the Birth Rate

Where previously the small open economy would import the excess capital needed for investment goods for the new workers in the economy, now we are only able to import half of what we need. This means that to some extent our investment goods will be spread over more heads, as happened in the closed economy. This means

Plate 11 – An Increase in the Population Growth Rate

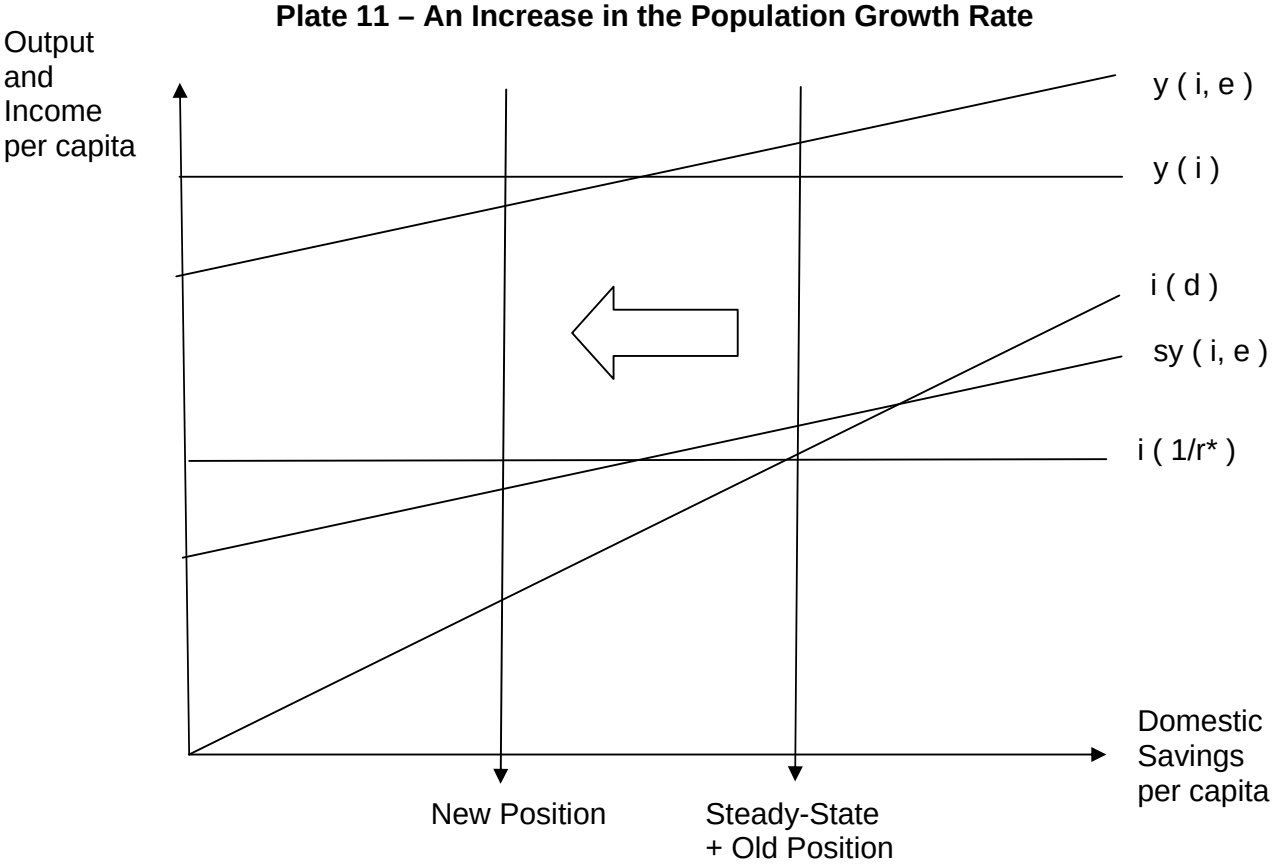
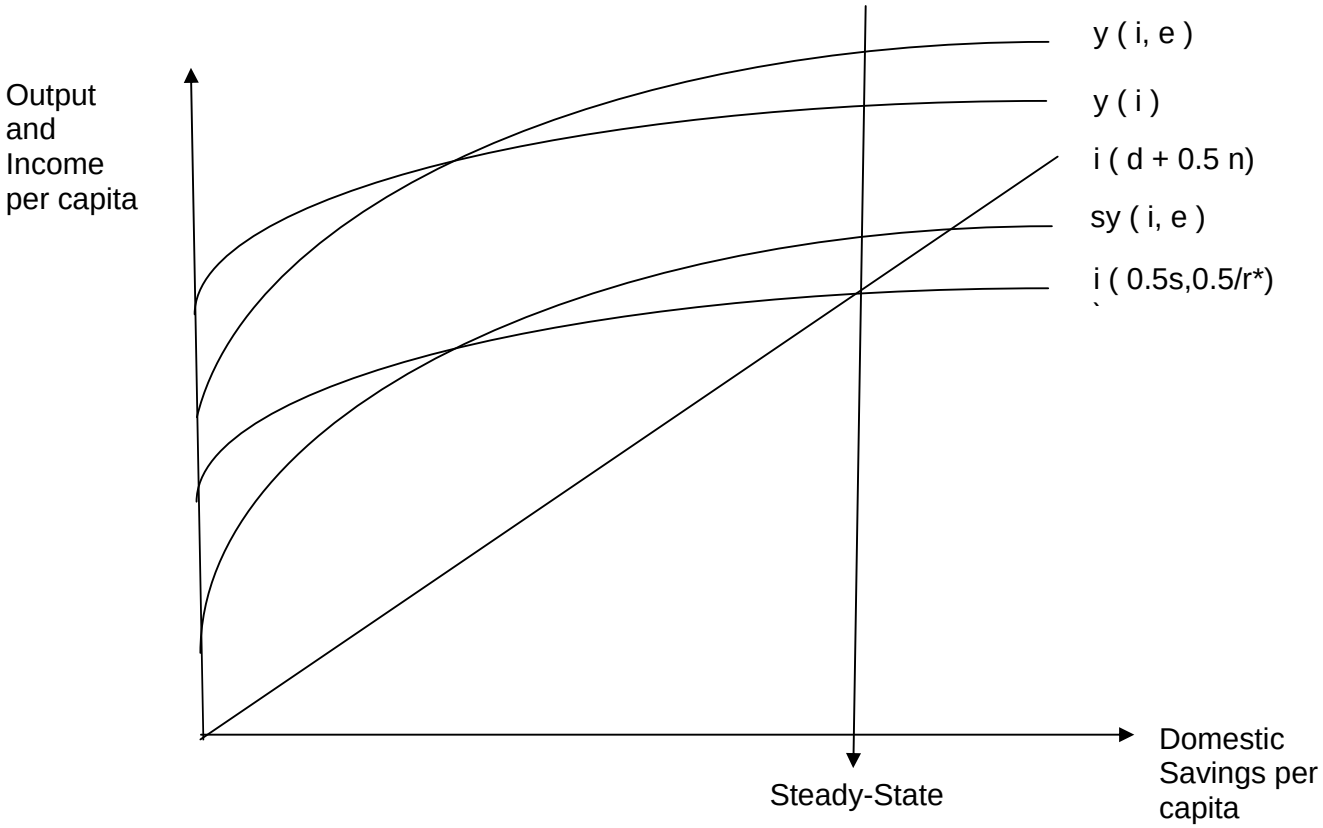


Plate 12 – A Small Half-Open Economy



that an increase in the population growth rate leads to fewer investment goods per capita, yet more compared to the closed economy. Since the division of investment goods over a larger number of people occurs linearly, so it follows that the necessity to spread investment goods out has a linear effect on the investment requirement function. That is to say that in the half-open, small economy the population growth rate will have half of the effect on the steady-state as it did in the closed economy.

Diminishing Returns and the Balance of Payments

Since we now are only able to import half of the investment we had previously in the small open economy from abroad, the case for diminishing returns returns. This means in effect that our domestic savings will now play a role in domestic investment since half of them are excluded from international investment projects by imperfect mobility.

Yet how imperfect is our imperfect capital mobility? This can be measured by the balance of payments. The capital account will be only half of the previous size, due to capital imports / exports being restricted. The size of the capital account also shows the size of the current account, assuming that flexible exchange rates are in place. This means that diminishing returns have half of their previous effect and that the axis is cut at the half-way point. All this is shown in the diagram in plate twelve.

Conclusion

Bringing together the findings of the theory as developed, the main point that jumps out is the quicker convergence to a higher steady-state. What is equally important though is the change in the drivers of growth, from capital accumulation and slow population growth, in an economy with often incremental increases in technology, to a much more competitive environment where investors seek out countries with comparative and macroeconomic advantages. An open economy though will not necessarily lead to quicker growth converging to a higher steady-state though. Mostly it will depend on the marginal efficiency of investment. This can be dramatically altered, for example, by migration of skilled or unskilled labour or macroeconomic frameworks. Indeed, even the immigration of average skilled labour can have a big

effect on an open economy. These comparative advantages are, however, even more fragile in an open economy, especially if they are based on tradable technologies, since, due to trade, these are easily introduced into product production abroad, eroding any comparative advantage. In this case the steady-state can swing back and forth wildly, meaning that each country is constantly having to assess their comparative advantages and keep ahead of competitors.

The theoretical developments in this theory are manifold. The main points are the defining of the steady-state with economic reasoning and the key linkages in variables by separating out capital into investment and saving and output into output and income, which are inter-related via the balance of payments. Equally important, the current account is often seen as being of immense long-term importance. While in the short-term adjustments to a large current account may be an extremely important consideration, in the long-term it is of relatively little importance and people may consider this finding one of the more difficult to accept. Furthermore, showing that the investment requirement function is still relevant, convergence, one of the main theoretical sticking points for mathematical models, is shown to be a lot quicker, but not instantaneous as had been the prediction of the mathematical models. Lastly, due to the simple to use graph, consumption can easily be read off due to the ease of national income accounting.

So what are the policy implications? These can be split into two categories. Firstly, the theory has to apply. This means that there has to be, as far as possible, perfect information, low transport and transaction costs, flexible exchange rates with no exchange controls and no tariffs or similar barriers to trade. Secondly, as Gordon Brown has acknowledged as Chancellor and Prime Minister of the United Kingdom, there has to be a concerted effort to provide a competitive macroeconomic framework and sustainable comparative advantages. The macroeconomic environment governs the framework for economic activity and ranges from the tax code, inflation and employment law through to fiscal policy. In enhancing comparative advantages this can normally be done in two ways. Firstly, there is action to support a strategic industry. An example of this would be the zoning of a technology park or the gifting of land by the government to a factory. Secondly, there is “pump-priming”, i.e. providing the basic ingredients that allow comparative advantages to develop. An

example of this would be improving the transport infrastructure, or increasing the stock of human capital by increasing government spending on education.

References

Barro, R.J., Mankiw, N.G., Sala-i-Martin, X.X. (1995), *Capital Mobility in Neoclassical Models of Growth*, American Economic Review, Vol. 85, Issue 1, Pages 103-15.

Carlberg, M. (1997), *International Economic Growth*, Contributions to Economics, Physica-Verlag.

Dornbusch, R., Fischer, S., Startz, R. (2000), *Macroeconomics*, Eighth International Edition, McGraw-Hill/Irwin.

Ramsey, F.P. (1928), *A Mathematical Theory of Saving*, Economic Journal, Vol. 38, No. 152, Pages 543-59.