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A Gust of Trust

On Trust and Growth

Anna Callenberg & Valentin Zulj
Supervised by Karin Bergman

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Abstract

The purpose of this paper is to investigate the effect of trust on the predictive power of the Solow growth model, extended to use human capital as a growth inducing factor. Previous literature widely agrees that non-economic variables are, indeed, of great importance in predicting the growth of economies, and hence, we choose to develop a growth model taking the levels of trust into account, seeing as there is no recognized model doing so. Because of the influence that trust – and variables similar to it – has on macroeconomic theory and thinking, we find it is suitable to extend the array of economic growth models in the way described. To conclude, we assert that the extension of the Solow model does in fact improve our possibilities of predicting values of real output per capita, at least when it comes to Sweden.

Key words: Economic growth, trust, Solow, macroeconomics

Table of Contents

1	Introduction	4
1.1	Statement of Task	5
1.2	Disposition	5
2	Background	6
2.1	Selecting a Model	7
3	Theory	8
3.1	The Solow Model with Human Capital	8
3.2	Introducing τ	9
3.3	The Solow Model Extended by Trust	10
3.4	Growth Accounting	14
4	Data	14
4.1	Trust	14
4.2	GDP and Capital	16
4.3	Savings Rate	16
4.4	Education	16
4.5	Parameters	16
4.6	Growth Rates	18
4.7	Calculations	18
5	Results and Analysis	20
5.1	The Swedish State	21
5.2	Evaluating the Trust Model	22
6	Concluding Remarks	24
	References	26
	Appendices	27
	Appendix A	27
	Appendix B	27
	Appendix C	28

1 Introduction

In many ways, economic growth is a fundamental part of our society of today. Companies seek it, politicians try to create it and citizens are often prone to demand it. In that sense, the study of economic growth is a highly interesting and expedient focal point of a bachelor's thesis in economics.

Over the years, the academic field of economic growth has been evolving and expanding, this is perhaps best shown by the substantial number of emerging economic growth models produced since the 1950s. The models are similar in the sense that they try to predict and explain economic growth, but vary in the sense that they account for different factors in the process of doing so. The original Solow model is an economic growth model that describes output as a function of time, capital and labour. Since it first saw the light of day, the original model has been extended to include technology, and later on even human capital, as factors affecting the levels of output. These extensions proved out to be a success, seeing as the augmented models have been tested to be empirically effective [Mankiw et al., 1992]. However, the predictive power is still not perfect, and we believe that an additional variable measuring trust – or social capital – might make the model even more accurate.

Trust is a highly interesting variable which is intertwined with macroeconomic thinking, and overall, there are many social matters and macroeconomic phenomena associated with trust that can be believed to affect the state of the economy. Yet, there is no established growth model that includes trust as a variable, even though previous literature has presented evidence and indications that trust could, and has indeed, been a driving force in the growth of economic output. Not only through its role in the carrying out of transactions, first suggested by Nobel laureate Kenneth Arrow – who claimed that every transaction has an element of trust to it [Arrow, 1972], but also in affecting other growth mechanisms such as the accumulation of human capital, innovation and institutional efficiency, as has been asserted by Knack and Keefer [1997], Zak and Knack [2001] and Christian Bjørnskov [2013], among others. As stated, the augmented Solow model takes both technology and human capital into account in predicting output levels. Hence, we believe that it can easily be extended to include a trust variable, giving it a multiplying effect on human capital, and through that, on the technological level.

In this thesis, we will investigate Swedish economic growth over a time interval stretching from the beginning of the 1980s to the late 2000s. This is partly due to the natural bias that comes with being born and raised here, and partly due to the fact that the data on economic and non-economic variables – such as trust – are easy to obtain for a relatively wide interval of time. This, of course, is crucial in the study of economic growth, since the core of the subject revolves around long run development.

Finally, our extended model proves out to provide a closer fit to the actual GDP series, leading us to conclude that social capital could indeed be a factor to take into account in the future of economic thinking – perhaps most importantly when it comes to economic growth.

1.1 Statement of Task

In short, the purpose of this thesis can be summarized by three bullet points

- Extend the above mentioned Solow model, adding a variable measuring trust
- Estimate series showing equilibrium output per capita in Sweden, using the simpler model and our extended model
- Compare the results of our estimations to determine which model gives the best predictions of GDP per capita

1.2 Disposition

The disposition of this thesis intends to be as straightforward as possible. We begin by giving a background on our topic, and previous research regarding the relationship between trust and growth. After that, we motivate our choice of model, and proceed by briefly summarizing the Solow model we use as our baseline, to give a better understanding of the idea of our thesis.

In sections 3.2 and 3.3 we discuss the possibilities of introducing trust to the Solow model, and later use our extended production function in order to derive expressions for the new steady state level of output per capita, and the rate at which it grows. We conclude the theoretical section through describing the theory of growth accounting, which is used to compute the technological levels needed to estimate our models.

Moreover, section 4 provides a short summary of the data used, and how it has been processed in order to fit the requirements of our calculations. Also, there is a short section describing the way in which we have made our calculations, and what software has been used in the process.

Furthermore, we dedicate a section to interpreting and analyzing the results acquired through performing the calculations described. We begin by giving a quick overview of the results, before we discuss whether the results are valid in relation to the state of the Swedish economy. Finally, we evaluate our model, and deliberate the range and limitations of the results produced, in order to draw the conclusions given in section 6.

2 Background

In present time, trust is an issue close to hand. No matter where we put our eye, there is always some sort of trust related issue that comes to mind, whether it be Donald Trump's approval ratings, trust that the news we read are reported in an honest and objective manner, or trust in our interactions with other people. Thus, trust seems to be of ever growing importance to us, and the study of it is considered to be timely.

In 2017, the Edelman trust barometer was named "*Trust in Crisis*", and the headline of the 2018 report was "*The Battle for Truth*" [Edelman, 2018]. Trust can be measured in a variety of ways, depending, of course, on what dimension of trust that is of interest. The Edelman reports focus largely on trust towards the media, NGOs and governments, but their results seem to indicate that a turn in trust is in the making. This thesis, however, will focus largely on the trust found between people in everyday situations – or interpersonal trust, but the data we have acquired suggest that the downward movements of trust levels extend to the category of trust that we choose to study as well. Judging from the titles of the Edelman reports, we are led to believe that a decreasing trend when it comes to trust levels is not desirable, and that it will have negative effects on society. Hence, we want to examine how trust is expressed in the context of economic growth, and to see whether a trust variable will affect the reliability of a growth model in general.

The focal point of our thesis will be the Swedish economy. In recent times, many issues that might have affected the trust levels in Sweden have arisen. The most recent one, perhaps, is the emergence of alternative media and the concept of fake news. These media outlets provide different perspectives and compromise objectivity, claiming to supply alternative facts. The relativization of facts might be a factor affecting trust levels in society.

Furthermore, unrest in the Middle East – perhaps mainly the civil war in Syria – has been the cause of an unmatched stream of refugees into Sweden. This is another factor that might well cause fluctuating trust levels. The constant inflow of new cultures and languages, coupled with the mobility of migrants and the hardships encountered in the process of giving them a safe place in society, might lead to changing trust levels among migrants as well as among natives. In their 2015 article, Danish researchers Peter Thisted Dinesen and Kim Mannemar Sønderskov show that ethnic diversity in the micro-context reduces social trust. Hence, the rising levels of refugees in Sweden can be thought to affect trust levels. Of course, social trust is not only explained by ethnic diversity, but diversity can be used as an example showing that social trust might indeed be on the turn. Thus, a study of how trust affects the performance of the Swedish economy is suitable.

The introduction of trust into economic thinking is quite reasonable. Studying the performance of an economy is an issue that very much falls into the scope of macroeconomics, and thus, accounting for trust is logical. In macroeconomic theory, variables such as expectations and trust play a significant role. Expectations in the sense that the expected inflation, for example, is used in setting

and negotiating wages. Trust in the sense that the efficiency of monetary (and in some cases fiscal) policy to some extent depends on how much the population trusts in the ability of a monetary measure to be successful, and the competence of central bankers. Hence, we believe that adding a trust variable to an existing model striving to predict the output of an economy could be suitable in order to capture the effects of events such as those described above on output.

In their paper *Does Social Capital Have An Economic Pay-Off?*, Stephen Knack and Philip Keefer [1997] examine if, and when, social capital matters for economic performance, using empirical data. The results presented strengthen the assumption that trust is an important variable when analyzing and calculating economic growth, showing a significant relationship between trust and growth. Also, in the countries studied that possessed well-functioning institutions, a greater rate of income equality, higher levels of education, and ethnically homogeneous populations, trust levels were higher [Knack and Keefer, 1997].

It seems that trust, alongside other non-economic variables, has an impact on economic growth. Also, the variables in question may well be connected to each other. The first connection that comes in mind, perhaps, is the one between individuals and institutions. A well-functioning market needs stable and reliable institutions, both economic ones, lowering transaction costs and facilitating interpersonal exchanges, but also political ones, that reduce the number of market failures and allocate resources in the best way possible. Such well-performing and effective institutions rely on citizens beliefs in the institutional structure and, in turn, the institutions must be responsive and keen to the citizens beliefs and requests in order to enable continuous long-term growth [North, 2005]. Moreover, trust can be claimed to facilitate innovation and technological progress through reducing time spent on monitoring any misconduct of partners and competitors, allowing more time to engage in innovation and technological processes, which are an important basis for technologically driven economies [Knack and Keefer, 1997, Bjørnskov, 2013].

Furthermore, trust can be an important variable in increasing the accumulated human capital, which will, according to Barro [2001], increase the labour productivity and, in line with neoclassical growth theory, increase the economic output. This effect is achieved through various channels. In 1988 James Coleman presented a relationship showing that higher trust levels mean that fewer students drop out of school. Also, Eiji Yamamura [2009] argued that a higher level of trust increases cooperation and exchange of ideas at work.

2.1 Selecting a Model

Having established that trust can in fact affect economic growth, we need to consider the ways in which it does so, and how it can be expressed through expanding an existing growth model. As mentioned above, trust can be thought of as a human capital enhancing factor, and thus, we believe a model that includes human capital as a factor in determining output is suitable. Considering our well established options, we conclude that the model best suited for a bachelor's thesis is Robert Solow's model, to which human capital has been added

by Gregory Mankiw, David Romer and David Weil [1992] to include human capital. This is because we believe that trust is best expressed as an growth inducing factor through the effect it can have on the levels of human capital in an economy. Further discussion of the implications that come with introducing the trust variable into the augmented Solow model is given in section 3.2.

Our hypothesis is that the augmented Solow model would perform better if it was expanded with a variable that takes the level of trust in the economy into account. It is highly conceivable that trust has a major impact on our consumption patterns and our willingness to carry out financial transactions, but also in facilitating accumulation of human capital. In an economy characterized by a high level of trust, cooperation and the exchange of ideas among people should be at their highest, seeing as high trust levels allow us to speak more freely, and openly ventilate our problems without running the risk of embarrassment or theft of intellectual property. Therefore, we plan to extend the Solow model with a trust variable, τ , and then compare how its predictions relate to those that can be made using the 1992 model that only uses human capital.

3 Theory

3.1 The Solow Model with Human Capital

Robert Solow has been a fundamental thinker when it comes to growth economics, and his models are often thought to have sparked the entire academic discipline. This thesis will focus mainly on the augmented Solow model, where human capital is considered to be a contributing factor to GDP per capita. Hence, this section will aim to give some background and explain the augmented Solow model.

Solow's augmented model stems from a production function where human capital is accounted for. The real output of the economy is defined as

$$Y = K^\alpha (AH)^{1-\alpha}, \quad (1)$$

where Y is the real GDP, K is the level of real capital, A is the level of technology, and H is human capital. Further, H is defined as $e^{\psi u}L$, where u gives the level of education, ψ measures the quality of the education attained, and L is the size of the population. The purpose of the Solow model is to express the level of real output per capita when an economy is in its steady state – or equilibrium. The steady state is defined as a state in which all economic variables grow at constant rates. This does not necessarily mean that they will grow at the same rate, but that, unless some sort of shock hits the economy, their rate of change will not be altered. If we denote the growth in an arbitrary variable – say Z – as g_Z , the steady state means that g_Y , g_K , g_A , and g_H will all be constant.

In his model, Solow makes several assumptions regarding the growth of certain variables. Firstly, the augmented Solow model assumes that the population grows exogenously, at a rate of $\frac{\dot{L}}{L} = n$. In this case, the "dot" operator denotes the change in a variable. Hence, for the arbitrary variable Z , \dot{Z} can be thought

of as $Z_t - Z_{t-1}$ or $\frac{\partial Z}{\partial t}$, where t is the time component of the variable in question. The growth in technology is given exogenously as well, and is denoted by g .

Solving the augmented Solow model in order to find an expression for real steady state GDP per capita – or y^* – results in the equation given below:

$$y^* = \left(\frac{s}{\delta + n + g} \right)^{\frac{\alpha}{1-\alpha}} A e^{\psi u}. \quad (2)$$

The derivation of this expression will be left out of this thesis, mainly because the derivation of our extended model is very similar to it. Hence, interested readers are advised to read section 3.3 of this paper, or have a look in a book introducing growth economics, for example Jones and Vollrath's *Introduction to Economic Growth* [2013].

As can be seen in Equation (2), the steady state output per capita depends on the levels of technology and education – A and $e^{\psi u}$ respectively – but also on real capital. The fraction at the left shows that a quicker growth in population will reduce the level of GDP per capita, which is intuitively reasonable since the population sharing the output will grow faster than the output itself. Also, the depreciation of real capital will make for a lower level of output in equilibrium, this is shown by the inclusion of δ in the denominator. Finally, the savings rate, s , contributes to higher output. The model assumes that the share of income which is not used for consumption will be used in the formation of capital, and through that, the savings rate will be a positive factor in production output.

In this section, we have given a brief summary of Solow's augmented model. Further discussion will be provided in section 3.3.

3.2 Introducing τ

The purpose of our thesis is adding a trust variable, τ , to the Solow model in order to find out how it affects the predictive powers of the model. In adding the trust variable, we consider two possible options. Firstly, we consider the possibility of adding τ to the exponential term of H , which is defined in connection to Equation (1). Doing this would mean we define H as $e^{\psi u + \tau} L$, and that we add trust as a component affecting the quality – or productivity – of schooling. While such an idea might not be completely alien, seeing as trust in teachers and the educational system could well be a contributing factor when it comes to the quality levels of education, we believe that that sort of trust is rather hard to measure, and the effect of trust in the educational system on economic growth is not what this paper set out to investigate. Hence, we move on to the second option under consideration.

The second option implies that trust has a multiplicative effect on the levels of human capital in an economy, and that the effect on human capital spills over to the level of technology as well. Using mathematics, we now define H as $e^{\psi u} L \tau$, meaning that trust levels in the economy will affect human capital in such a way that it is a direct inflator, as opposed to going through the system of education. We find that this is a more suitable way of introducing trust to

our model, since it manages to stress the effect trust has on cooperation and the exchange of ideas, affecting the levels of human capital. Because of this, we choose to extend the model through multiplying τ into the production function. The process, and theoretical results, of doing so will be presented in section 3.3.

Finally, we use trust data collected by the World Value Survey (WVS) and the European Value Survey (EVS). A more detailed description of the data, as well as of how it is used, is given in section 4.1. However, we want to add a brief discussion of the type of trust measured, and how come we choose to include this particular form of trust in our model. The line of reasoning follows from the preceding paragraph, in that we want to introduce an aspect of trust that influences the formation – and accumulation – of human capital. Hence, we find that interpersonal trust – or trust in fellow citizens and the people making up our surroundings – is best suited. This is because we assert that interpersonal trust is what determines the spirit of our interactions with other persons, and thus, logically, also our cooperation and the exchange of ideas. This argument provides stronger grounds for using the multiplicative effect of τ , since the effect of trust on the quality of education is not as clear cut and direct.

3.3 The Solow Model Extended by Trust

Following the discussion given in section 3.2, extending the human capital version of the Solow model yields the following production function:

$$Y = K^\alpha (AH)^{(1-\alpha)}, \quad (3)$$

where $H = e^{\psi u} L \tau$. Y gives the value of real GDP, A is the technological level, and H denotes human capital. Furthermore, L is the size of the population, u is the level of education, ψ measures the productivity – or quality – in education, and τ is the trust variable we have added. We choose to multiply τ into the expression for human capital given in the original model, seeing as we believe that trust makes for a greater exchange of ideas, and that it will work as a driving force in developing human capital.

In his model, Solow makes several assumptions regarding the growth of certain variables, all of which will be kept in our extended model as well. Firstly, the augmented Solow model assumes that the population grows exogenously, at a rate of $\frac{\dot{L}}{L} = n$. The growth in technology is given exogenously as well, and is denoted by g . Furthermore, the change in real capital is assumed to be affected by two parameters, δ and s . δ measures the depreciation rate of real capital, and s gives the savings rate – or the share of gross capital formation. Mathematically, the accumulation of real capital is given by

$$\dot{K} = sY - \delta K, \quad (4)$$

meaning that the change in capital is the difference between newly formed and depreciated capital.

In order to find an expression giving the real GDP per capita, y , we divide both sides of the production function – given in Equation (3) – by the size of the population, L :

$$\begin{aligned}
y &= \frac{Y}{L} = \frac{K^\alpha (AH)^{1-\alpha}}{L} \\
&= \frac{K^\alpha (AL\tau)^{1-\alpha} e^{\psi u(1-\alpha)}}{L^\alpha L^{1-\alpha}} \\
&= k^\alpha (A\tau)^{1-\alpha} e^{\psi u(1-\alpha)}.
\end{aligned} \tag{5}$$

Note that $k = \frac{K}{L}$. To find the growth rate of y , we take the natural logarithms of Equation (5), and then differentiate with regards to time, which yields the following result:

$$\begin{aligned}
\log(y) &= \alpha \log(k) + (1 - \alpha)(\log(A) + \log(\tau)) + (1 - \alpha)\psi u \log(e) \\
&\Leftrightarrow \alpha \log(k) + (1 - \alpha)(\log(A) + \log(\tau)) + (1 - \alpha)(\psi u) \\
&\Rightarrow \frac{\partial \log(y)}{\partial t} = g_y = \alpha g_k + (1 - \alpha)(g_A + g_\tau),
\end{aligned} \tag{6}$$

since u and ψ are assumed to be constant. As the steady state growth rates are constant for all variables, it means that g_y is constant in equilibrium, as are g_k , g_A and g_τ . In our model we assume that g_A and g_τ are exogenous. However, to further simplify the expression for g_y , we consider the accumulation of real capital given in Equation (4), and calculate the growth rate of real capital:

$$g_K = \frac{\dot{K}}{K} = \frac{sY - \delta K}{K} = s \frac{Y}{K} - \delta.$$

In the steady state, all growth rates are constant. Seeing as s and δ are given parameters, K and Y need to grow at the same speed for g_K to be constant. This implies that $g_Y = g_K$, and hence that $g_y = g_k$. Substituting the result into Equation (6), we get

$$\begin{aligned}
g_y &= \alpha g_k + (1 - \alpha)(g_A + g_\tau) \\
&= \alpha g_y + (1 - \alpha)(g_A + g_\tau) \\
&\Leftrightarrow (1 - \alpha)g_y = (1 - \alpha)(g_A + g_\tau) \\
&\Leftrightarrow g_y = g_A + g_\tau,
\end{aligned} \tag{7}$$

showing that in equilibrium, the growth rate in GDP per capita is dependent on the growth of technology and the growth in trust, which is in line with the results found by Knack and Keefer [1997], showing that trust has a significant effect on economic growth.

Having found the growth of real output per capita, the derivation of y^* itself is initiated. In order to derive an expression giving y^* , a couple of state variables are introduced. The state variables – \tilde{y} and \tilde{k} – are defined in such a way that they do not change when the economy is in its steady state. Mathematically, this means that $\dot{\tilde{y}}$ and $\dot{\tilde{k}}$ are both equal to 0 in equilibrium. Further, $\tilde{y} = \frac{Y}{AH}$,

where $H = e^{\psi u} L \tau$. In his augmented model, Solow assumes that $h = e^{\psi u}$ is constant, which is an assumption we keep in our model. However, keeping the results found in Equation (7) in mind, we see that g_y depends on the growth rates of both technology and trust in the extended model. Hence, the growth in trust has to be accounted for in order to make sure the state variables are constant in equilibrium. We begin by finding \tilde{y} :

$$\tilde{y} = \frac{Y}{AH} = \frac{K^\alpha (AH)^{(1-\alpha)}}{(AH)^\alpha (AH)^{(1-\alpha)}} = \left(\frac{K}{AH}\right)^\alpha = \tilde{k}^\alpha. \quad (8)$$

In Equation (8) we see that \tilde{y} is a function of \tilde{k} . Knowing that both state variables are constant, or perhaps more importantly that $\dot{\tilde{k}} = 0$, in equilibrium, we can use $\dot{\tilde{k}}$ to find the value of output per capita. Thus, we proceed by finding $\dot{\tilde{k}}$, using the fact that $\dot{\tilde{k}} = \frac{\partial \tilde{k}}{\partial t}$:

$$\dot{\tilde{k}} = \frac{\partial \tilde{k}}{\partial t} = \left(\frac{\dot{K}}{AhL\tau}\right) = \frac{K}{AH} \left[\frac{\dot{K}}{K} - \frac{\dot{A}}{A} - \frac{\dot{L}}{L} - \frac{\dot{\tau}}{\tau}\right].$$

In the expression given above, all variables are functions of time, though t notation has been left out in order to save space. In the process of differentiation, an extended form of the quotient rule is used, rendering the expression found on the right hand side above. In proceeding, we note that the change in a variable, divided by the initial level of that same variable, gives its growth rate. Returning to our arbitrary Z variable, this means that $\frac{\dot{Z}}{Z} = g_Z$. Therefore, the calculation can be carried on as follows:

$$\begin{aligned} \dot{\tilde{k}} &= \frac{K}{AH} \left[\frac{sY - \delta K}{K} - g - n - g_\tau \right] \\ &= s \frac{Y}{AH} - (\delta + g + n + g_\tau) \tilde{k} \\ &= s\tilde{y} - (\delta + g + n + g_\tau) \tilde{k}. \end{aligned}$$

As stated above, $\dot{\tilde{k}} = 0$ in equilibrium, meaning that

$$\begin{aligned} 0 &= s\tilde{y} - (\delta + g + n + g_\tau) \tilde{k} \\ \Leftrightarrow s\tilde{y} &= (\delta + g + n + g_\tau) \tilde{k}. \end{aligned}$$

Thus, through substitution, we can use the result found in Equation (8) – namely that $\tilde{y} = \tilde{k}^\alpha$ – to find that

$$\begin{aligned} s\tilde{y} &= s\tilde{k}^\alpha = \left(\delta + g + n + g_\tau\right)\tilde{k} \\ \Leftrightarrow \frac{\tilde{k}}{\tilde{k}^\alpha} &= \frac{s}{\left(\delta + g + n + g_\tau\right)} \\ \Leftrightarrow \tilde{k} &= \left(\frac{s}{\delta + g + n + g_\tau}\right)^{\frac{1}{1-\alpha}}. \end{aligned}$$

Again, we use Equation (8) to find that

$$\begin{aligned} \tilde{y} &= \tilde{k}^\alpha \\ \Rightarrow \tilde{y} &= \left(\frac{s}{\delta + g + n + g_\tau}\right)^{\frac{\alpha}{1-\alpha}}. \end{aligned}$$

From the definition of the state variables, we deduce that

$$\begin{aligned} \tilde{y} &= \frac{Y}{AH} = \frac{Y}{Ae^{\psi u} L\tau} \\ &= \left(\frac{Y}{L}\right) \left(\frac{1}{Ae^{\psi u} \tau}\right) = \frac{y}{Ae^{\psi u} \tau} \\ \Leftrightarrow y &= \tilde{y} A e^{\psi u} \tau, \end{aligned}$$

and, finally, we find an expression giving the real output per capita in our extended trust model:

$$y^* = \left(\frac{s}{\delta + g + n + g_\tau}\right)^{\frac{\alpha}{1-\alpha}} A e^{\psi u} \tau. \quad (9)$$

The steady state expression found in Equation (9) is rather similar to that of the original model - found in Equation (2), the only difference being the introductions of τ and g_τ . These inclusions are both reasonable, seeing as a growing level of trust can be assumed to make for a greater exchange of ideas, and through that to more time being spent on education, as was discussed in section 2. Thus, having a slight negative effect on output, rendered by g_τ . Also, the level of trust is assumed to affect the level of human capital, which is shown through multiplying by τ at the end.

3.4 Growth Accounting

Measuring the technological level in an economy is a complex issue, seeing as the term *technology* is not particularly well defined. In this thesis, we will use what is called *growth accounting* in order to determine at which level the technology stands in the Swedish economy.

Consider the production function given in Equation (3). The production function shows that, in theory, the level of output in an economy can be broken down into three factors, namely real capital, technology and human capital. Using the expression for real GDP per capita – found in Equation (5) – we can derive an expression that enables us to theoretically determine the level of technology in the Swedish economy. If we define h as $e^{\psi u}$, we can perform the following operations

$$\begin{aligned} y &= k^\alpha (Ah\tau)^{1-\alpha} \\ \Leftrightarrow A^{1-\alpha} &= \frac{y}{k^\alpha (h\tau)^{1-\alpha}} \\ \Leftrightarrow A &= \frac{1}{h\tau} \left(\frac{y}{k^\alpha} \right)^{\frac{1}{1-\alpha}}. \end{aligned} \tag{10}$$

Hence, we can use data which is more readily available to calculate the level of technology in the Swedish economy and, through that, estimate the equilibrium values presented in sections 3.1 and 3.3. We calculate technological levels using the respective production function of each model, although the calculation is only demonstrated in the case of our extended model.

Naturally, the method of growth accounting has flaws. As can be seen, it assumes that the part of GDP per capita that does not arise from real or human capital is generated by the technological level. In real life, this is a simplification, seeing as there are several other factors that are likely to affect the level of y . However, within the theoretical framework of our model, these are the only variables with any real effect. Hence, we choose to make this simplification in order to estimate our model.

4 Data

This section provides a brief overview of the data that has been used in our thesis. For a complete index referencing the source of each data series, see the table presented in appendix A.

4.1 Trust

The trust data we use in our calculations has been collected by the World and European Value Surveys respectively [WVS, 2015, EVS, 2015]. The data have been collected over six waves, beginning in 1981, and allow for a longitudinal study of trust in different countries. We use the share of respondents who accepted that, in Sweden, "*most people can be trusted*" for each wave, in order

to create an index showing how trust has developed over time. The data are shown in Table 1.

The waves differ somewhat in length, and we only have one value per wave. However, we have chosen to assume that over each wave, the share of people who agree with the above mentioned statement grows – or decreases – at the same rate. Doing this, we have been able to interpolate, giving us estimated values for each year during the time interval that has been studied.

For example, during the wave stretching from 1981 to 1984, 52.1% of respondents were positive, and during the following wave – 1990-94 – 59.6% of respondents were positive. We assume that at the beginning of wave 1, namely in 1981, 52.1% of Swedes felt most people could be trusted, and that the respective share was 59.6% at the start of the second wave in 1990. Using these values, we have calculated the average growth in trust per year, and used it for interpolation purposes. In this specific case, the calculation was made as follows:

$$\begin{aligned}
 0.521 \cdot x^6 &= 0.596 \\
 \Leftrightarrow x^6 &= \frac{0.596}{0.521} \\
 \Leftrightarrow x &= \sqrt[6]{\frac{0.596}{0.521}} \\
 &= 1.0227
 \end{aligned}$$

meaning that the trust grew at an average rate of 2.27% per year over the six year period. To calculate the trust level for each year between 1984 and 1990, we interpolate by the following standards:

$$\tau_t = 0.521 \cdot (1.0227)^t,$$

where $t \in \{0, 1, 2, 3, 4, 5, 6\}$. The same principle is used in order to find values for the remaining years, the only difference being the rates of change in trust.

Finally, we construct an index series and use it as the final input of trust into our extended model. In the series, we use 1981 as the baseline, and then use values of later years in order to gain the relative magnitude of trust for each year.

In Table 1, the column headings have been shortened in order for the table to fit into the typesetting of the page. Thus, a short explanation of them might be in place. Firstly, *N/A* means that there is no answer, while *Don't Know* means that the respondent is indifferent to the statement. Furthermore, *Most People* indicates that respondents agree that most people can be trusted, while *Careful* means that respondents think that you cannot be careful enough in dealing with other people.

Wave	Missing Value	N/A	Don't Know	Most People	Careful	% Positive
1981 - 84	0	0	78	497	379	52.1
1990 - 94	0	103	0	624	320	59.6
1995 - 98	0	0	93	1217	714	60.1
1999 - 04	0	8	111	755	313	63.6
2005 - 09	0	40	0	655	308	65.3
2010 - 14	4	10	20	760	412	63

Table 1: Data on trust, as given by the World and European Value surveys

4.2 GDP and Capital

Data on real GDP and capital levels feature in growth accounting, and in order to find values of A – see Equation (10) – we use data found in the Penn World Table [Feenstra et al., 2015]. Real GDP is measured on the output side of the economy, and together with the capital stock, it is given at constant 2011 prices, counted in US Dollars.

4.3 Savings Rate

The savings rate is an important factor in determining the level of GDP, since it is critical in the accumulation of real capital. Naturally, it is found in the numerator of both equations giving steady state values of y , i.e. Equations (2) and (9), since a higher savings rate means that more resources will be present in the formation of capital, and through that, the levels of output will increase. The data used for measuring the savings rate, s , is provided by the Penn World table [Feenstra et al., 2015], giving a complete set of annual values for the entire time period studied.

4.4 Education

We find data regarding educational attainment in Barro and Lee’s database [Barro and Lee, 2012]. The database supplies data on the average years of schooling among the part of the Swedish population that is 15 years or older. Due to the difficulties in measuring educational attainment, data points only exist for every fifth year, meaning that $u \in \{u_{1980}, u_{1985}, \dots, u_{2010}\}$. Hence, we use the method described in section 4.1 in order to interpolate and gain values that stretch the entire width of our time interval.

4.5 Parameters

In Equation (9) there are three parameters that need to be taken into account – δ , α and ψ . Penn World Tables [Feenstra et al., 2015] supply data regarding

δ and α , while ψ needs to be estimated manually.

δ measures the depreciation of capital over time, and enters the equation for steady state output per capita through the accumulation of capital. Naturally, a larger δ will lead to less output, since less capital will be available for use in production. As mentioned above, estimates of δ have been found in the Penn World Tables [Feenstra et al., 2015]. Further, α is defined in such a way that $(1 - \alpha)$ measures the share of production value that is paid to the labour used in production. α is often thought to be somewhere in the neighbourhood of $\frac{1}{3}$, but in this thesis we use the values for α , again provided by the Penn World Tables.

When it comes to ψ , an estimation has to be made. In section 3.4 we defined $h = e^{\psi u}$, and in doing so we rewrite the production function in Equation (3) to $Y = K^\alpha (AhL\tau)^{1-\alpha}$. Now, considering h , we perform the following operations:

$$\begin{aligned}
 h &= e^{\psi u} \\
 \Rightarrow \log(h) &= \psi u \log(e) \\
 \Leftrightarrow \log(h) &= \psi u \\
 \Rightarrow \frac{\partial \log(h)}{\partial u} &= \psi
 \end{aligned} \tag{11}$$

Equation (11) shows that the natural logarithm of h can be expressed as a linear equation, meaning that ψ can be estimated as the percentage change in the level of education. That is, the parameter ψ can be estimated using an ordinary OLS regression. For Sweden, ψ is estimated to be 0.0719. A scatter plot of the level of education against time is shown in Figure 1, together with the best fit line estimating ψ .

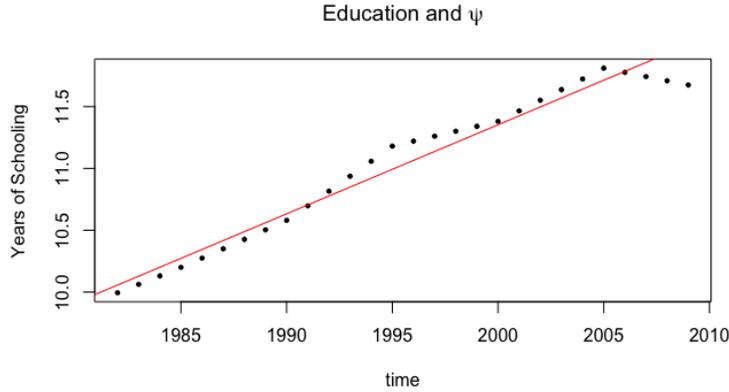


Figure 1: Estimate of ψ

4.6 Growth Rates

Equation (9) states that, in order to estimate values of y^* , the growth rates in the technological level, the population, and trust – g , n and g_τ respectively – are needed. Numbers on the size of the Swedish population are retrieved from the Penn World Tables [Feenstra et al., 2015], while the technological level is computed using the theory of growth accounting described in section 3.4. The data used in the process of growth accounting has been described throughout this section.

Calculating the growth rates and using them in Equations (2) and (9), we encountered a problem, particularly with regards to the technological growth. As can be seen in Figure 2, during some periods the technological growth was negative, i.e. the level of technology was decreasing. Plugging these negative values of g into the steady state equations will render negative values of the ratio at the very beginning of the expressions on some occasions, and as the ratio is raised to $0 < (\frac{\alpha}{1-\alpha}) < 1$, some values of y^* will not be defined. Hence, we decide to use the average yearly growth rates, estimated using OLS regressions. The growth rates are estimated using the regression equations given below:

$$\begin{aligned}\log(A_t) &= \beta_0 + \beta_1 t + \varepsilon_t \\ \log(L_t) &= \gamma_0 + \gamma_1 t + \eta_t \\ \log(\tau_t) &= \zeta_0 + \zeta_1 t + \nu_t \\ \log(\hat{A}_t) &= \theta_0 + \theta_1 t + \kappa_t\end{aligned}$$

where t is the time component of each series and ε_t , η_t , ν_t , and κ_t are error terms. A_t gives the technological level calculated using the production function extended by trust, and \hat{A}_t was computed using the initial production function. Seeing as we use the logarithmic values of each variable, the coefficients measuring the marginal effect of time – β_1 , γ_1 , ζ_1 , and θ_1 – will show the average yearly growth in each variable. The ordinary least squares estimates are given in Table 2.

β_1	γ_1	ζ_1	θ_1
0.01481	0.00394	0.00577	0.02206

Table 2: OLS estimates of average yearly growth rates

Doing this allows us to estimate the GDP series without having to remove missing values. Figure 2 – on page 19 – shows the logarithmic values of technology and population plotted against their time components, as well as the best fit lines, whose derivatives estimate the growth rates.

4.7 Calculations

Following the description of the data used, we conclude this section through giving a summary of the calculations performed in order to obtain the results

presented in section 5. All calculations are made using the statistical software package R – and RStudio, which is an extension to it. The thesis has been typeset using \LaTeX .

The time series showing the actual level of GDP per capita in Sweden is calculated using data retrieved from the Penn World Table [Feenstra et al., 2015]. As stated above, the GDP is measured on the output side of the economy, and to find the real output produced per capita we simply divide the real output of every given year with the corresponding population number. Put mathematically, this means we compute $\frac{Y}{L}$.

As for the two Solow series, we use R to write functions meant to repeatedly calculate the values of y^* given in Equations (2) and (9). Doing this, we acquire vectors containing yearly steady state values predicted by the original Solow model as well as our model using the trust variable. Finally, we plot the three series in the same window, resulting in Figure 3.

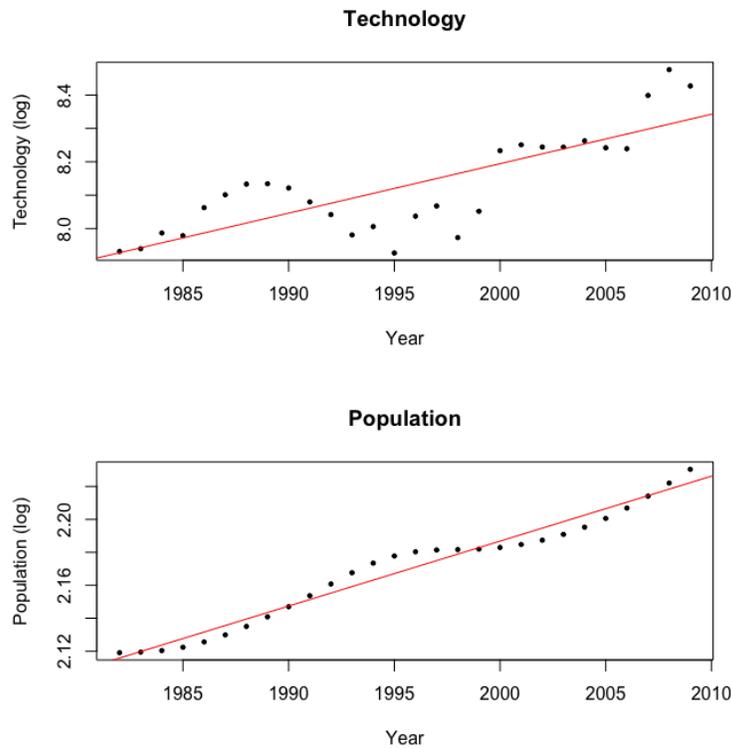


Figure 2: Growth rate estimates

5 Results and Analysis

Performing the calculations described in section 4.7, the series shown in Figure 3 are obtained. As can be seen, the predictions made by our model generally seem to provide a better fit to the actual GDP series. This result can be seen more clearly if the deviations of the estimated series from the actual values are computed. This measure of deviations is defined as follows:

$$\lambda = \sum_{t=1982}^{t=2009} (y - \hat{y}), \quad (12)$$

where y denotes the actual GDP per capita series, and \hat{y} the estimated series. Values of λ are given in Table 3. As can be seen, the sum of deviations is greater when using the ordinary Solow model, again, supporting the claim that our model makes for better predictions.

What is important to note is that the two models produce similar estimates at the very beginning of the time interval. This is because we use an index series when introducing τ into the model, and index series which initially takes on values very close to 1. Hence, the trust variable will not come into effect until later. The reason the estimates of the trust model are somewhat lower at first is the addition of g_τ in the denominator of the expression given in Equation (9).

	Original Model	Trust Model
λ	209181	154855

Table 3: Measures of the deviation from actual GDP per capita

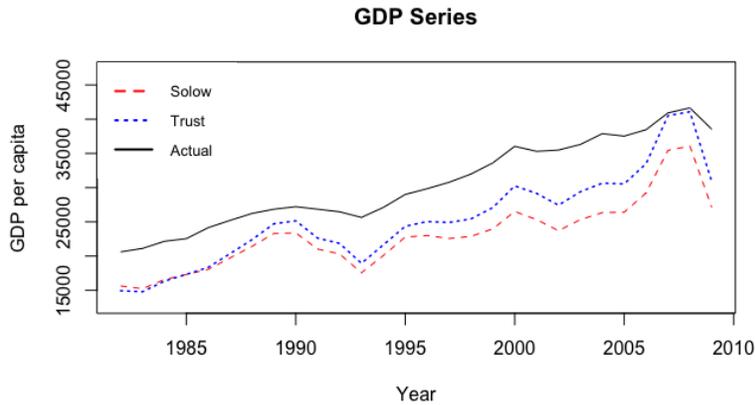


Figure 3: GDP time series

However, it is important to discuss what theoretical implications our results will have, and whether we actually want the steady state predictions to follow the actual curve very closely. Of course, this depends on whether we believe the Swedish economy is in its steady state or not. Hence, we first need to contemplate the steady state issue a bit further.

5.1 The Swedish State

In sections 3.1 and 3.3, we stated that the predictions made by the two models are strictly equilibrium values, this follows from the fact that the mathematics used in deriving the models do not hold up otherwise. Because of this, it is critical to gauge whether the Swedish economy is actually in a long run equilibrium. If it is not, there is no true way of determining which of the models presented provide better predictions, since there is no convectional way of finding out how far the economy is from its steady state. Thus, this section will provide a discussion in order to figure out where the Swedish economy finds itself in relation to its steady state.

In section 3.1, we defined the steady state as a state where all economic variables grow at constant rates. That, of course, suggests that the growth rate in GDP, g_y , should be constant if the Swedish economy is indeed in its steady state. Looking at the actual GDP series shown in Figure 3, we see that the real output per capita has been growing at a relatively constant rate during the years studied in our thesis. In other words, the gradient of the curve representing the series is constant on average. Of course, there have been a few dips and booms – perhaps most notably the crises of the 1990s and the late 2000s – but overall, the growth rate has not fluctuated very much. To further illustrate this point, a line could be fit to the series just as in section 4.6. Such a figure is shown in Appendix B. Thus, the empirical change in real output over time provides us with firm grounds in indicating that the Swedish economy has indeed been in – or around – its steady state over the years stretching from 1982 to 2009.

This line of argumentation can be strengthened by Sweden’s history when it comes to politics and the economy. Over time, Sweden has been a forerunner regarding political and economic stability, allowing governments, politicians, and economists to study the economy closely in order to find out how it works. This accumulated knowledge should, we claim, contribute to a balanced economic growth path. Having such experience in the field, and being so familiar with the issues of economic growth and the Swedish economy, politicians and economists are well equipped to carefully guide the economy, keeping it close to equilibrium over time. This assertion is perhaps best supported by the actions of the Swedish government during the great recession of the late 2000s. Through its knowledge of the intricate mechanisms composing the Swedish economy, the government managed to minimize the damage caused by the crisis. Hence, we can assume that sound economic policy has been implemented over the time interval covered by our thesis, again implying the economy should find itself close to its steady state.

Furthermore, the estimated series both suggest that the Swedish output per

capita has been higher than steady state output throughout the entire period of study. This, however, seems to be somewhat out of place considering the theory of convergence, described by Jones and Vollrath [2013] in their textbook on economic growth. According to theory, an economy producing output levels higher than those suggested by the steady state is expected to stagnate and converge to the steady state level of output. In Figure 3, however, the series of actual GDP per capita values does not seem to be stagnating, but rather to keep growing at the same pace. This, clearly, supports the argument that the economy is in fact rather close to its steady state.

Finally, we believe we are able to claim that the Swedish economy is indeed rather close to its steady state – if not even in it. Having come to this conclusion, we can proceed in analyzing the performance of our extended model in comparison with that of the augmented Solow model.

5.2 Evaluating the Trust Model

Assuming that the Swedish economy is in a steady state, the trust extended model provides a better fit to the actual GDP series than the original model with human capital. In essence, it is likely that the model gives better predictions when trust as a non-economic variable is taken into account. As stated in section 2, previous literature widely agrees that such variables are of major importance for fluctuations and developments concerning economic growth. Accordingly, the addition of trust to human capital, which in itself is a non-economic variable, is likely to capture unique patterns of variation and constitutes a good complement and explanation as to why the accumulated human capital increases — or decreases — which in turn affects economic growth. In effect, the dotted (blue) line representing the extended model in Figure 3 constantly gives better predictions and improved accuracy throughout the entire period that has been studied, except for the first few years. The reason for the lower predictions might well be the lower levels of trust in that time, but it might also stem from the index series used to enter trust values into the model. The problems of the index series are discussed further below.

Moreover, there are improvements that can be made to increase the accuracy in the extended model. For instance, we found that in this case, interpolating the data measuring trust was a suitable option to process the data, given that no annual values were available. Interpolating entails some issues and it is reasonable that the model would be more accurate if the problem was approached in another way. Since interpolation reduces the variation of trust within every given wave to a pre-determined growth path, annual data could provide rewarding information with regards to the impact of trust in economic growth. We believe that trust, as a non-economic variable, captures some aspects of social and economic change that is not readily apparent when only economic variables are used. Hence, the availability of annual data would clearly help build a better model, and through that make for better predictions.

Looking at Figure 3, the series produced by the trust model grows faster than that computed using the original Solow model. This in itself is not a

particularly strange result, seeing as we add a component to the growth rate of y in Equation (7). Theoretically, an issue of the model could be that this added component makes for an uncontrollable growth in predicted values, as there is no clear restriction to it. However, seeing as trust is measured through a ratio which, of course is bound to take a value on the interval $[0, 1]$, the predictions are prevented from exploding. Furthermore, we believe that trust levels will eventually reach a sort of stability, fluctuating around some long term value, unless they are made to change by an outside shock. Such behaviour might be supported by the data given in Table 1, where trust reaches its peak at roughly 65%, only to fall back to 63% during the next wave. It is hard to say whether this decrease is solely a result of the great recession, or whether it is in fact a natural levelling out. This remains to be seen, and an answer could be given through the release of the seventh wave of value surveys, scheduled for the near future. The main point, though, is that trust levels are indeed bounded, and will not interfere with the predictive abilities of our model.

Actual	Solow Model	Trust Model
0.02509	0.02342	0.0299

Table 4: Average growth rates in actual and estimated GDP per capita

In Table 4 the average growth rates projected by the two models are given, together with the average growth rate of the actual GDP per capita series. The growth rates have been estimated according to the method described in section 4.6. Of course, the model is supposed to predict levels of both y^* and g_y in order to be as good a model as possible. Looking at the growth rates, we see that the original Solow model underestimates the growth rate, although the estimation error is rather slight. Our extended model overestimates the growth rate by close to half a percentage point. This, naturally, indicates that the model is not as suitable as first thought. There is, however, a possible reason as to why that is. The index series used to enter trust data into the model is, as stated in section 3.3, anchored by the trust level of 1981, meaning that the first values of τ used in the model are relatively close 1. Hence, there is a chance that the model underestimates the first couple of values, and that trust truly comes into effect in the later stages of the time interval. As a result, the possibly underestimated values could be points of high leverage, meaning that they have a relatively large effect on the linear estimation of the growth rate, and through that lead to skewed results. If a better way to introduce the trust variable into the model is found – a way in which the effect of trust is immediate – the initial estimations made by the trust model might well be written up, meaning the OLS regression line would have a smaller gradient, perhaps closer to that of the actual GDP per capita series, this issue is illustrated in Appendix C. In short, the discrepancy in growth rates might well be a flaw of the model, but it is as likely to be a result of limiting data.

It is important to note that in our results, we have calculated a new steady

state value for each year of investigation. This might seem rather counter-intuitive in some senses, but in our opinion it is indeed a reasonable approach. Theory assumes that when an economy reaches its steady state it will remain in that state forever, given that no shock comes along and forces the economy into a transitional phase, moving to a different steady state. Of course, what constitutes these shocks is up for discussion, and it might be that shocks have to be relatively substantial to force an economy out of equilibrium. However, the theoretical model(s) used in our thesis suggests that the steady state level of output per capita is affected by the factors present in Equations (2) and (9), and since our sources provide yearly data on many of these factors, we believe that the changing values mean that the steady state is changing as well.

With regards to continuing the evaluation of our model, we believe that a duplication of our calculations would be of interest, changing only the fact that each wave of the trust barometers is thought of as a steady state. In essence, this comprises calculating six steady state levels – using both models – and making a comparison of differences. This would reduce the loss of information incurred through interpolating the trust data, but it would also mean wavelly averages would need to be estimated, perhaps resulting in a loss of information greater than that entailed through interpolation.

Lastly, to further develop the results of this thesis, we think that the Solow model used could be replaced by a model of new growth theory – perhaps the one presented by Paul Romer, in which technological growth is explained endogenously, is most suitable. This extension of our result would consist of adding τ to the expression of technological accumulation, and seeing as Sweden is a country spearheading the development of new technologies, using Romer’s model could make for even better predictions.

6 Concluding Remarks

With the studies of, among others, Stephen Knack and Philip Keefer [1997] in mind, we were inspired to extend an economic growth model with a variable of trust. Trust had been proven to have a significant effect on economic growth, and as a generally non-economic, but still rather macroeconomic, variable, we thought it suitable to see what benefits trust could bring to a model of economic growth. Eventually, the decision fell upon extending Robert Solow’s model accounting for human capital as a growth enhancing factor, and the focal point of this thesis has been to examine what effect the trust variable τ will have when incorporated into the model.

As such, the product of our thesis is not so much a list of hard boiled results, but rather an implementation of the model on the Swedish economy, and a discussion as to whether using trust as a predictive variable is reasonable or not. As discussed in section 5 – and shown in Figure 3 – the predictions of our extended trust model are generally more accurate than the ones given by the Solow model induced with human capital, given that the Swedish economy has indeed been in-or-around its steady state. Furthermore, the deviations –

measured using Equation (12) and presented in Table 3 – suggest that our predictions are in fact closer to reality than those of the original model.

Naturally, however, there are limitations to the model we have solved; the greatest one, perhaps, being the collection of trust data. Trust is a complex phenomenon, and determining what type of trust to use in a model, as well as measuring it in an effective way is challenging in itself. This is illustrated by the fact that the data available to us comes in waves of three years or more.

Thus, the trade-off between the benefits gained from better prediction and the effort required to collect good trust data needs to be considered.

Nevertheless we believe that, all in all, the model provides a ground for greater use of variables such as trust and social capital in the sphere of economic growth, as well as a bait for extending the research on trust related variables. Finally, we hope that this thesis will serve as a reminder that trust might well be a factor to take into consideration in the proces of writing policy documents – be they economic or political in a wider sense.

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Appendix A

Appendix A provides a table showing where the data used in our calculations has been retrieved from, citing each source explicitly.

Type of Data	Source	Reference(s)
GDP	Penn World Tables	[Feenstra et al., 2015]
Real Capital	Penn World Tables	[Feenstra et al., 2015]
Population	Penn World Tables	[Feenstra et al., 2015]
Education	Barro and Lee	[Barro and Lee, 2012]
Trust	WVS and EVS	[WVS, 2015, EVS, 2015]
Savings Rate	Penn World Tables	[Feenstra et al., 2015]
δ	Penn World Tables	[Feenstra et al., 2015]
α	Penn World Tables	[Feenstra et al., 2015]

Table 5: Sources of Data

Appendix B

Appendix B contains a figure plotting real GDP per capita against time, as well as a line fitted using OLS regression, in order to complement the analysis of section 5.1.

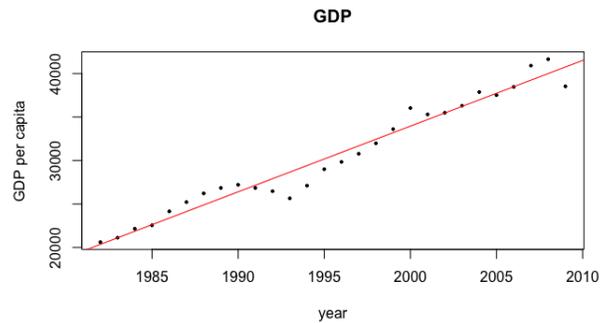


Figure 4: GDP per capita

Appendix C

In Appendix C, we provide an illustration of the issue discussed in section 5.2. Imagine the growth of actual GDP per capita is given by the red - dotted - line, and that the blue line shows the growth in our estimated GDP values. The upper figure shows the situation given in our result section, and the other figure shows a scenario where trust immediately comes into effect, and the estimated values are written up from the very beginning. As can be seen, the writing up due to the initial effect makes for a flatter line, giving a better estimate of the growth in actual output per capita.

