An Analysis of The Solow Growth Model, Comparing Japan and Morocco between 1990 and 2020

Link to article: IMPact | An Analysis of The Solow Growth Model | Web
Digital Object Identity (DOI): https://doi.org/10.82406/247v-kn72

Module: Advanced Macroeconomies

Jessica Ellis[1] and Prof Shrabani Saha[2]

[1]Year 3 Undergraduate Student, BSc in Economics

[2]Professor of Development Economics

Lincoln International Business School

University of Lincoln

Abstract

This paper applies the Solow Growth Model in a comparative analysis between Japan and Morocco during 1990 to 2020. By using data on GDP per capita, consumption to GDP ratios as well as investment to GDP ratios that are sourced from the World Bank and International Monetary Fund, the study analyses how well the Solow Growth Model's predictions hold in explaining growth in developed versus developing economies. The results indicate that Japan, which represents developed economies, has characteristics that are consistent with the Solow model's steady state equilibrium. Examples of this include stable growth and diminishing returns to capital. In contrast, Morocco, a developing country, shows slower and more volatile growth. Morocco had shown inefficiencies in capital allocation along with high consumption levels, which limits the model's explanatory power. To account for these discrepancies, institutional quality and corruption are considered, factors which are omitted from the original Solow framework. These findings show the importance of governance along with technical progress when analysing growth, as it is found that while the Solow Growth model is a useful tool, it alone is not enough to fully explain growth patterns, particularly in developing countries.

Keywords: Macroeconomics, Solow Growth Model, Economic Growth, Corruption, Capital Accumulation.

Introduction

The Solow Growth Model, developed by Robert Solow (1956), was the main theoretical tool for economic growth until the 1980s. It is still considered the benchmark model of growth (Saha, 2024) and the starting point for much of the current analysis of economic growth, despite the fact that it itself is rather limited and does not account many characteristics in modern economics. It suggests that economic growth is driven by capital accumulation, labour force growth and technological progress. The Solow Growth Model's key prediction is the fact that as economies accumulate more capital, they experience diminishing returns, meaning that GDP growth slows, that is unless technological progress intervenes. This analysis is comparing two countries, with Japan representing a developed economy, from the OECD group, and Morocco representing a developing economy, with the data analysed spanning 30 years from 1990 until 2020. The data includes real GDP per capita, which will show the growth that each of the countries has had; the ratio of consumption to GDP, which will show consumption behaviour and patterns; and the ratio of investment to GDP for each of the countries, which will show the behaviour of investment. It can then be evaluated whether the Solow Growth Model's predictions hold in both of these differently structured economies. All data is sourced from the World Bank's World Development Indicators Database or the International Monetary Fund.

Project Background

The understanding of the mechanisms of macroeconomics is a fundamental goal of macroeconomic research. The Solow Growth Model is one of the most widely used theoretical frameworks for examining how economies expand over time. This is an important analysis as it helps policy makers make informed decisions to ensure growth

targets are met. This research is particularly relevant given ongoing disparities between developed and developing countries; especially in the current wake of global economic disruptions. The aims of this study are to evaluate how well the Solow Growth Model explains growth in different economic and institutional contexts, so that it can be understood if growth patterns are universally explained by capital, labour and technology. If not, do real world conditions such as governance and corruption effect the model's predictive power and deserve more consideration by policy makers? This research contributes to the debate about the limitations that neoclassical models face in the modern complex and globalised economy.

Literature Review

Empirical literature has extensively tested the Solow Growth Model across countries with mixed success. Barro et al (1992) found that there is evidence for conditional convergence among developed countries, especially those with similar savings rates, educational levels and population growth. Their findings support the Solow Growth Model's prediction of diminishing returns to capital and a tendency towards a steady state. Mankiw, Romer, and Weil (1992) extend the model to include human capital. This improved the model's ability to fit cross country data has further explained the divergence observed in real world growth patterns. However, the model has been found not to fit as well when applied to developing countries. In these countries capital is not always efficiently allocated, savings rates are low and technological adoption is limited by weak institutions. Acemoglu, Johnson, and Robinson (2001) argue that institutional quality, such as governance and corruption plays a fundamental role in shaping growth trajectories. These ideas set the basis to the analysis that is completed in this study.

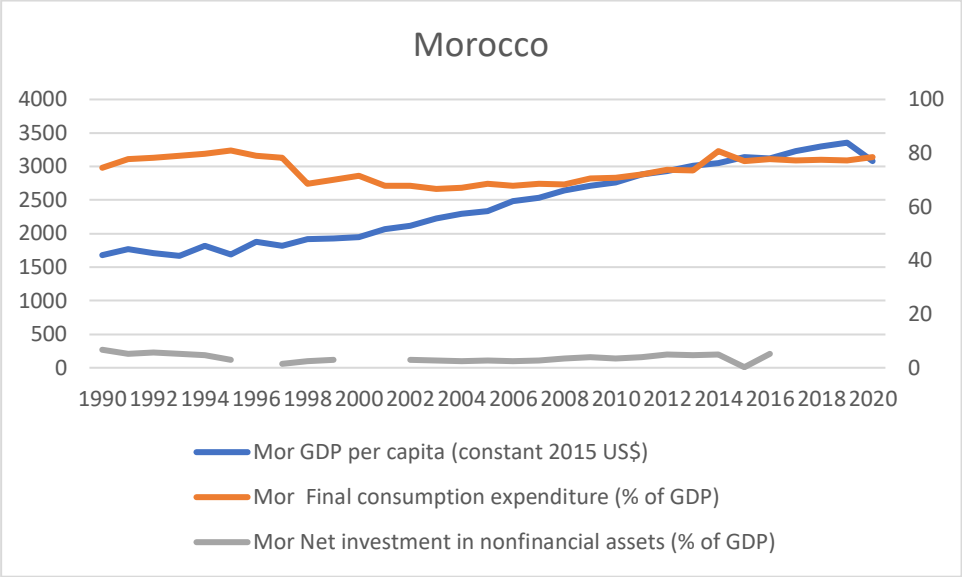
Methodology

This study has a comparative quantitative approach. It uses the Solow Growth Model as the analytical framework to assess the patterns on economic growth in Japan and

Morocco over the thirty-year period from 1990 to 2020. The selection of these two countries was deliberate, with Japan representing a developed economy, with its stable institutions and efficient capital markets (Qureshi et al, 2024) and Morocco representing a developing economy with weaker governance and capital allocation inefficiencies (Ezzahid and Nihou, 2017), creating a contrast that allows for critical evaluation of the Solow Model's assumptions across varying institutional and economic contexts.

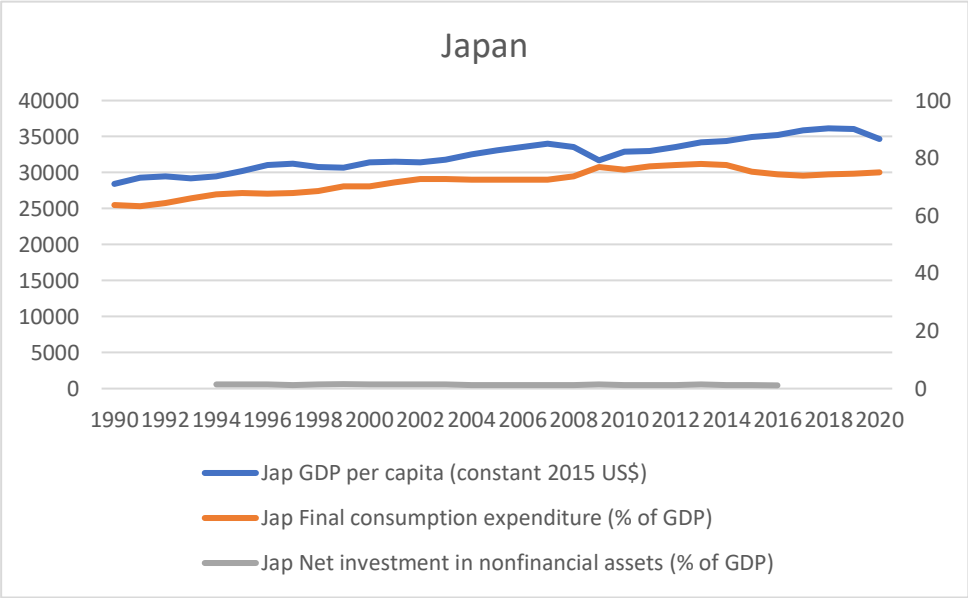
Both countries have reliable data available, ensuring a robust and comparable dataset for meaningful cross-country analysis. The data was collected from the World Bank's World Development Indicators and the International Monetary Fund's financial statistics databases, as reliable secondary sources. Three variables were taken for each country: real GDP per capita, investment as a percentage of GDP and the final consumption expenditure as a percentage of GDP. These variables act as proxies for output, capital accumulation and consumption/saving behaviour, which are three key aspects of the Solow Growth Model's structure. This data was then interpreted by observing the changes in the variables to see if the data behaved in accordance to the following hypothesis: developed countries exhibit behaviour that aligns with the Solow Growth model while developing countries demonstrate a partial deviation from the model.

Results



Data Sources: World Bank (2024a), World Bank (2024b), International Monetary Fund (2024a)

Figure 1- Morocco



Data Sources: World Bank (2024c), World Bank (2024d), International Monetary Fund (2024b)

Figure 2- Japan

The key observations from the graph in Figure 2 representing Japan's data include the fact that Japan shows consistent growth, with GDP per capita stabilising at high levels after only occasional fluctuations. The most noteworthy of these fluctuations being the 1997 Asian Financial Crisis (Brown, 2024) which can be seen on the graph by a GDP decrease at that time. However, this was a fairly limited decrease and soon returned to a steady increase, another key GDP fluctuation being during the 2008 financial crisis, but this effected economies globally and while a larger GDP dip can be seen, it once again spiked back up quite quickly. This is what would be expected from a developed economy such as Japan. Japan's consumption to GDP ratio remains relatively stable which reflects once more that it is a more mature economy, as it has balanced consumption and saving patterns, suggesting economic resilience and advanced financial systems. The investment to GDP ratio shows that investment levels are consistent but with moderate growth, which suggests diminishing returns to capital accumulation.

To interpret this with the Solow Growth Model it could be said that Japan is in a steady state, meaning that increases in their capital yields limited additional return, which is a key determining factor when looking at if the steady state holds, and makes it seem evident that in this instant it does. It is also evident that it holds due to Japan's long term GDP growth appearing to be primarily driven by technological progress opposed to increased capital per worker, which is once again consistent with Solow's predictions. Additional observations are that there is clear institutional strength, which ensures efficient capital allocation, as well as governance quality appearing to be good, with transparent policies and there being institutional stability which helps with there being sustained growth (Qureshi et al, 2024). And as previously mentioned, economic shocks, while impactful, are none the less mitigated effectively. This all ties in with a steady state with limited corruption, which is a healthy and developed economy.

Whereas the key observations of the graph in Figure 1, showing Morocco's data, reveals slow but steady growth, periods of stagnation can be seen in the late 1990s and then again around early 2020. Morocco's GDP per capita is overall much lower than Japan's, with at the start of the thirty years looked at in 1990, Morocco's GDP was

only 1600 USD while Japan's starting GDP was about 28,000 USD, which is a vast difference and shows the overall difference in scale of the two economies and really demonstrates Morocco as a developing country. Morocco's consumption to GDP Ratio remains consistently high which suggests that there is limited savings capacity as the economy is likely a consumption driven economy, meaning that the consumers spend all of what they earn which is what, in turn, drives the economy. The investment to GDP ratio shows that investment levels are relatively low and volatile, indicating that there are structural inefficiencies in capital allocation, which suggests that there is corruption at play.

A key factor that is not included in the Solow Model is corruption and governance quality. This is a factor that will also be investigated within this analysis to understand if it explains any observed differences that occur. Corruption effects growth as it means that there is a misallocation of public investment, so the economy will not receive the full multiplier effect that it has potential to get. Corruption can be in the form of spending being directed away from important areas such as health care and education, and instead into high-cost infrastructural projects which create less productivity have more room for overpaid contractors (Saha and Sen, 2019). It can also be in the form of bribery taking and general lack of proper democracy. While it has been argued that corruption actually has limited effect on growth itself (Khan and Jomo, 2000), it can still be used as a tool to explain differences observed that would have otherwise been unexplained by the Solow Model.

The interpretation of Morocco's graph, in accordance to the Solow Model, is that Morocco is in an earlier phase of the capital accumulation process, with potential for investment driven growth that is yet untapped. The inefficiencies in capital allocation and technological lag slow down growth rates to less than their potential. The Solow model also assumes efficient capital allocation, which, as previously mentioned, is not always seen to be the case. In this incidence the Solow Model holds partially, as while some of the model predictions seem to hold, others do not, such as diminishing returns to capital are not fully seen due to structural inefficiencies and growth remains very

much constrained by low saving rates, government inefficiencies and technological gaps.

An additional observation that is not included in the model is institutional weakness. Morocco is considered a politically stable country, but with it scoring 38 on a scale of 0 being highly corrupt and 100 being very clean and ranking 94th out of 180 countries in Transparency International's Corruption Perception Index in 2022 (Transparency International, 2023), where the highest ranked is expected to have the cleanest public sector, so corruption clearly remains a challenging factor. However, the Moroccan government is aware of this ongoing problem and have set up measures to address it, including the establishment of an anti-corruption commission as well as an ethics committee (Department of Business and Trade, 2023), which shows that they are keen on attracting legitimate future investors in order to continue their growth.

Corruption is a large issue effecting developing countries such as Morocco's growth and its lack of inclusion in the Solow Growth model is a reminder in the simplicity of the model compared to how complicated modern economies often are. Other unaddressed factors include the dependence on agriculture increasing their economic vulnerability, as well as poor relationships with neighbouring countries meaning an increased chance of economic shocks (Kichikeche and Mafamane, 2024), with a key example of this being its border with Algeria being closed, which is expected to create yearly losses across North Africa of billions of dollars (Mezahi, 2021).

My Learning Experience

This project has enhanced my ability to recognise academic journal structures, including how arguments are framed, evidence is presented, and conclusions are drawn. It has also strengthened my overall understanding of macroeconomic concepts, particularly how theoretical models like the Solow Growth Model are applied and tested using real-world data. I am now more confident in interpreting macroeconomic indicators and trends and in critically analysing the strengths and limitations of

economic models. These skills will support my future academic work and my interest in economic development.

Conclusion

In conclusion, the main differences observed between Japan and Morocco are that: Japan, as a developed country, experiences stable growth with diminishing returns to capital, as well as technology driven economic expansion. While in contrast, Morocco as a developing country, experiences volatile growth with inefficient capital accumulation and an over reliance on consumption. Japan has a transparent governance and strong institutions which support long term stability while Morocco's poor governance and corruption limit investment efficiency and economic growth. These results are both very much what would be expected to be seen from their conforming group.

The Solow growth struggles particularly in explaining Morocco's growth as it assumes that there is perfect capital markets and efficient allocation, which are conditions that are often unmet in developing countries such as Morocco. This means that overall Japan aligns closer with the Solow Growth Model. My recommendations for further growth with consideration with what has been seen in each country is for Japan to continue prioritizing innovation and research, and for Morocco to focus on institutional reforms, anticorruption measures and investment efficiency.

This analysis emphasises the importance of institutional quality and technological progress in achieving sustainable economic growth across different economic contexts. Further research should expand the sample size used and analyse the data of more developed and developing countries to get an improved over view on the validity of the Solow growth model. The current use of two countries is a limitation of this study as it makes it difficult to generalise the findings to all developed or developing countries, so while the contrast is useful for illustration, it may not capture the diversity of either group fully.

References

Acemoglu, D., Johnson, S., and Robinson, J.A. (2001). *The colonial origins of comparative development: An empirical investigation*. American economic review, 91(5), pp.1369-1401.

Barro, et al. (1992). *Capital Mobility in Neoclassical Models of Growth*. National Bureau of Economic Research. Available from: https://www.nber.org/papers/w4206

Brown, J. (2024). *Asian Financial Crisis: Causes, Response, Lessons Learned*. Investopedia. Available from: https://www.investopedia.com/terms/a/asian-financial-crisis.asp

Department of Business and Trade. (2023). *Overseas business risk: Morocco*. GOV.UK. Available from: https://www.gov.uk/government/publications/overseas-business-risk-morocco/overseas-business-risk-morocco

Department of Commerce. (n.d.a). *National Data: National Income and Product Accounts Tables*. U.S. Department of Commerce: Bureau of Economic Analysis. Available from: http://www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1#reqid=9&step=3&isuri=1&910=X&91=0&903=146&904=2008&905=2013&906=A.

Ezzahid, E. and Nihou, A. (2017). Capital deepening and efficiency in Morocco. Available from: https://mpra.ub.uni-muenchen.de/82143/

International Monetary Fund. (2024a). Morocco Net Investments in nonfinancial assets (% of GDP). International Monetary Fund, Government Finance Statistics Yearbook and data files.

International Monetary Fund. (2024b). Japan Net Investments in nonfinancial assets (% of GDP). International Monetary Fund, Government Finance Statistics Yearbook and data files.

Khan, M. and Jomo, K. (2000). *Rents, Rent-Seeking and Economic Development.* Cambridge University Press.

Kichikeche, A. and Mafamane, D. (2024). *External Shocks, Asset Prices, and Credit Dynamics Morocco: Insights from Disequilibrium Models*. SSRN. Available from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4834604

Mankiw, Romer, and Weil. (1992). *A contribution to the Empirics of Economic Growth*. Quarterly Journal of Economics. Available from: https://eml.berkeley.edu/~dromer/papers/MRW_QJE1992.pdf

Mezahi, M. (2021). *Letter from Africa: Lamenting the Algeria-Morocco border closure.* BBC. Available from: https://www.bbc.co.uk/news/world-africa-57467644

O'Neill, A. (2024). *National debt in relation to gross domestic product (GDP) in Japan 2019-2029.* Statista. Available from: https://www.statista.com/statistics/267226/japans-national-debt-in-relation-to-gross-domestic-product-gdp/

Qureshi, M. et al. (2024). *Japan financial sector assessment program, financial system stability assessment.* International Monetary Fund. Available from: https://www.imf.org/en/Publications/CR/Issues/2024/05/10/Japan-Financial-Sector-Assessment-Program-Financial-System-Stability-Assessment-548785

Saha, S. (2024). *Solow Model.* ECO3010: Advanced Macroeconomics. Lincoln International Business School.

Saha, S. and Sen, K. (2019). *The corruption–growth relationship.* United Nations University. Available from: https://www.wider.unu.edu/sites/default/files/Publications/Working-paper/PDF/wp-2019-65.pdf

Solow, R. M. (1956). *A Contribution to the Theory of Economic Growth*. Quarterly Journal of Economics, 70, 65-94. Available from: https://doi.org/10.2307/1884513

Transparency International. (2023). *Our work in Morocco*. transparancy.org. Available from: https://www.transparency.org/en/countries/morocco

World Bank, (2024a). *Morocco GDP per capita (constant 2015 US$).* World Bank national accounts data, and OECD National Accounts data files.

World Bank, (2024b). *Morocco Final Consumption Expenditure (% of* GDP). World Bank national accounts data, and OECD National Accounts data files.

World Bank, (2024c). *Japan GDP per capita (constant 2015 US$).* World Bank national accounts data, and OECD National Accounts data files.

World Bank, (2024d). *Japan Final Consumption Expenditure (% of GDP).* World Bank national accounts data, and OECD National Accounts data files.