# Global GDP Convergence Estimation

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## 1 Introduction

The behavior of differences in per capita GDP over time serves as the basis for literature surrounding cross-country convergence. Naturally, if differences in per capita GDP become less pronounced, there is evidence of convergence, such that countries reach comparable levels of growth and GDP per capita given enough time. This is of great interest in the field of economics, particularly regarding development, and prominently features a number of complex growth models to better explain how countries grow, and why certain countries grow faster than others. One common phenomena articulated in the existing literature is the catch-up effect—simply put, poor economies grow faster than rich economies and "catch up" in less time.

There are two generally accepted explanations for why this effect takes place, and has garnered a significant amount of attention in the literature to document the degree to which it holds in practice. The primary explanation regards the availability of capital. It is reasonable to assume that productivity is low in countries with little capital for use by workers. As such, with high potential for labor productivity in the presence of more capital, small increases manifest large productivity gains. Conversely, countries with high levels of capital see smaller gains from those increases because the initial, large gains have already been realized. Based on this logic, one could reasonably expect that, since poor countries have much greater potential for large productivity gains, and since richer countries are already seeing diminishing marginal returns from those increases, the GDP of the poorer countries will reach the levels realized by richer countries over time. Further, this effect can be compounded through technological innovation. While both richer and poorer countries stand to gain from technology increases, the adoption of new technologies in developing economies could bring about even higher gains in productivity, and lead them to surpass the levels enjoyed by richer countries.

Both explanations are grounded in the well-established in the work of Solow (1956) and Mankiw, Romer and Weil (1992). While a detailed discussion of the intricacies of the Solow model is outside the scope of this research there are a few key elements of these seminal works that serve as a theoretical foundation for the "catch-up" effect as discussed above. The Solow model focuses largely on the degree to which capital accumulation is a determinant of growth, and the pace at which countries reach a "steady state" of growth. In establishing this model, the concept of transition dynamics is developed—wherein countries that are farther from the "steady state" grow much faster than those closer to. Similarly, large injections of capital would serve to accelerate capital accumulation and therefore accelerate growth just as the catch-up effect dictates. Similarly, technological innovations, as they are employed in this subset of the growth literature, can serve to shift the production function of an economy outward and further incentivize growth. These elements are abstracted from the intricacies of the actual model (I encourage the reader to review the actual works to appreciate the role these elements serve in the larger model), but do serve as a theoretical benchmark for the catch-up effect.

To effectively measure the degree to which countries have/will converge both spatially and intertemporally, however, requires a corresponding measurement of real GDP that is comparable across countries—this is a quality that current national income accounts do not feature. This is a fundamental drawback of indices—while the allow one to easily visualize the behavior of real GDP over time for a given country, one cannot compare real GDP between countries based on these indices. Thus, analyses of this nature require a move from market exchange rates to exchange rates based on purchasing power parity (PPP). The use of "international dollars" constructed with recognizing this is a necessary condition for effectively assessing convergence, and requires data that is measured accordingly.

In this analysis, I seek to contribute to the existing literature on cross-country GDP convergence using a novel dataset that overcomes the measurement issues detailed above with two different methodological approaches to assess 1) the degree to which convergence has occurred over the past half-century and 2) the degree to which countries with levels of real per capita GDP below those of the "richer" or "developed" countries will experience convergence moving forward. This twofold approach assesses the pace and extent of intertemporal convergence to date, and the likely path of real per capita GDP forecasted into the future to determine likely dates where the theorized convergence will occur. Further, I seek to explore to what extent convergence is contingent on spatial considerations and, as such, sensitive to country selection in measurement.

# 2 Data & Methodology

Recognizing the difficulties associated with cross-country comparisons of real per capita GDP, my assessment of convergence defers to the work of the Maddison Project as the basis for my data in this analysis. The Maddison Project, started in 2010 by colleagues of the late Angus Maddison, The Maddison dataset features measurements of per capita GDP with exhaustive chronological depth (for instance, providing measurements back to AD1 for Italy). While the dataset does not provide this depth broadly, it is remarkably thorough for a wide selection of countries from 1950 to 2010, with more complete observations dating back to the mid-1800s for developed economies. Of note, the Maddison dataset utilizes Geary-Khamis International Dollars with the 1990 benchmark to ensure appropriate PPP-adjusted real per capita GDP figures for comparison of living standards across countries. The GK International Dollar is widely accepted in the discipline and serves as an excellent reference for analysis of convergence in this context.

Employing this dataset, I will defer to two different methodological approaches to assess the convergence of GDP over time. The first is the sigma approach from Boyle and McCarthy (1999) and Boyle and McCarthy (1997) that provides an easily constructed measure for the intertemporal change in per capita GDP. The sigma measure, constructed

$$\sigma = \left( \frac{\left[ \frac{stdev(GDPC_{ti})}{mean(GDPC_{ti})} \right]}{\left[ \frac{stdev(GDPC_{t0})}{mean(GDPC_{t0})} \right]} \right)$$

Where $stdev(GDPC_{t0})$ is the standard deviation of a per capita GDP across countries in a given cross-country selection of countries (more below) at a base year $t0$, and $stdev(GDPC_{ti})$ is the standard deviation of the per capita GDP across countries in same set of countries at time-period $i$. Standard deviations in both the base year and subsequent $i$-years are scaled by the mean of the per capita GDP in each respective time-period. We are interested how this measure of sigma behaves over time. By construction, $\sigma$ in the base year is equal to one—decreases in $\sigma$ are evidence of convergence over time, as the standard deviation between the per capita GDP decreases. If $\sigma_t = 0$, then, by construction, per capita GDP is equal across countries.

To assess the sensitivity of sigma to country selection, I will use several groupings defined in Table 1. Further, in order to more directly compare the results of the existing literature, I conduct the analysis for groupings detailed in Boyle and McCarthy (1999), using the World Bank Group typologies for upper, upper-middle, lower-middle, and lower income.

The second methodological approach undertaken in this analysis is the use of Vector Autoregressive Models (VARs). The use of the VAR approach provides remarkable flexibility for modeling per capita GDP over time, and affords us the opportunity to forecast per capita GDP in the long-run, such that one can empirically evaluate the time at which developing countries (e.g. China or India) will "converge" to the levels of developed economies like those of the United States and Germany. The VAR is specified as follows

$$Y_t = \alpha + \Gamma \cdot Yt - 1 + \Lambda \cdot time + \epsilon_t$$

In matrix form

$$\begin{bmatrix} y_{i,t} \\ \vdots \\ y_{n,t} \end{bmatrix} = \begin{bmatrix} \alpha_i \\ \vdots \\ \alpha_n \end{bmatrix} + \begin{bmatrix} \beta_i & \dots & \beta_i \\ \vdots & \ddots & \vdots \\ \beta_n & \dots & \beta_n \end{bmatrix} \cdot \begin{bmatrix} y_{i,t-1} \\ \vdots \\ y_{n,t-1} \end{bmatrix} + \begin{bmatrix} \lambda_i \\ \vdots \\ \lambda_n \end{bmatrix} \cdot t + \begin{bmatrix} \epsilon_{i,t} \\ \vdots \\ \epsilon_{n,t} \end{bmatrix}$$

Table 1: Countries used in analysis of convergence, 1952-2008

| G5* | G8* | G7 | G9* | Developing G20 | G20* | World |
|---|---|---|---|---|---|---|
| US | US | US | US | China | US | *141 |
| Germany | Germany | Germany | Germany | India | Germany | countries |
| Japan | Japan | Japan | Japan | Indonesia | Japan | with full |
| China | China | Canada | Canada | Saudi Arabia | Canada | data from |
| India | India | France | France | Turkey | France | 1952-2008 |
| | Canada | Italy | Italy | South Africa | Italy | |
| | Mexico | UK | UK | Argentina | UK | |
| | Brazil | | India | Brazil | India | |
| | | | China | Mexico | China | |
| | | | | Indonesia | | |
| | | | | South Korea | | |
| | | | | Saudi Arabia | | |
| | | | | Turkey | | |
| | | | | South Africa | | |
| | | | | Australia | | |
| | | | | Argentina | | |

*Denotes country groupings used in VAR specifications

Where $Y_t$ and $Y_{t-1}$ are $nx1$ matrices consisting of $n$-countries, and *time* serves as an exogenous trend variable for each respective country. The coefficient(s) of interest are contained in the $nxn$ $\Gamma$ matrix, which contains coefficients of all lagged log per capita GDPs from the $n$-countries in the specification and, therefore, their contribution in determining the log per capita GDP of each country. One advantage of using the VAR is the structure of the $\Gamma$ coefficient matrix—note that the main diagonal contains persistence effects (i.e. the regression coefficients corresponding to lagged values of the $i$th country's log per capita GDP), while the off-diagonal contains spillovers (i.e. the effects of other countries aberrations of log per capita GDP on the $i$th country's log per capita GDP). This allows us to essentially forecast the impacts of changes in other countries upon any given country. This is more empirically sound, as it is reasonable to assume changes in GDP do *not* occur in a vacuum.

Using the same country groupings detailed above in Table 1, I assess the sensitivity of the VAR specification to changes in country composition, as well as time period (using VARs for 1950-2010 and 1970-2010), and specification (using VAR(1) and VAR(3) based on lag structure). After determining coefficients from both VAR specifications for all time periods and country compositions, I will forecast the progression of log per capita GDP growth 100 years in the future, to 2210, to empirically evaluate the time at which relatively less "developed" countries "catch up." Lastly, I take advantage of the spillover components of the VAR coefficient matrix to assess impulse responses to unit shocks in log per capita GDP for 10 periods.

# 3 Results

From the sigma methodology with the groups specified in Table 1 above, convergence vis-à-vis sigma from 1952 to 2008 exhibits a marked decline. All series exhibit a negative average percent change in the sigma variable over the course of the sample, despite the mild resurgence in the 1980s that is observed in some of the samples containing primarily developed countries and despite the large increase in the developing G20 countries. The average percent change in sigma for the world sample of 141 countries is -2.5%, a decrease that is similarly experienced in the G20 (minus Russia) sample, the "G9" sample, the "G8" sample, and the "G5" sample. The two predominant outliers from this selection, the G7 and the "Developing G20," suggest another possible element of convergence. The G7 experiences, unequivocally, the greatest decline in sigma over the sample with an average percent change of -3.4%, a full percent higher than a majority of the samples. Further, while there is a clear *increase* in sigma from the 1950s through the early 1980s, the effect since has been a dramatic decrease to levels below those observed in all samples except for the G7, with an average percent change of -3.5% from 1980 through 2008. I posit this is evidence of "club convergence."

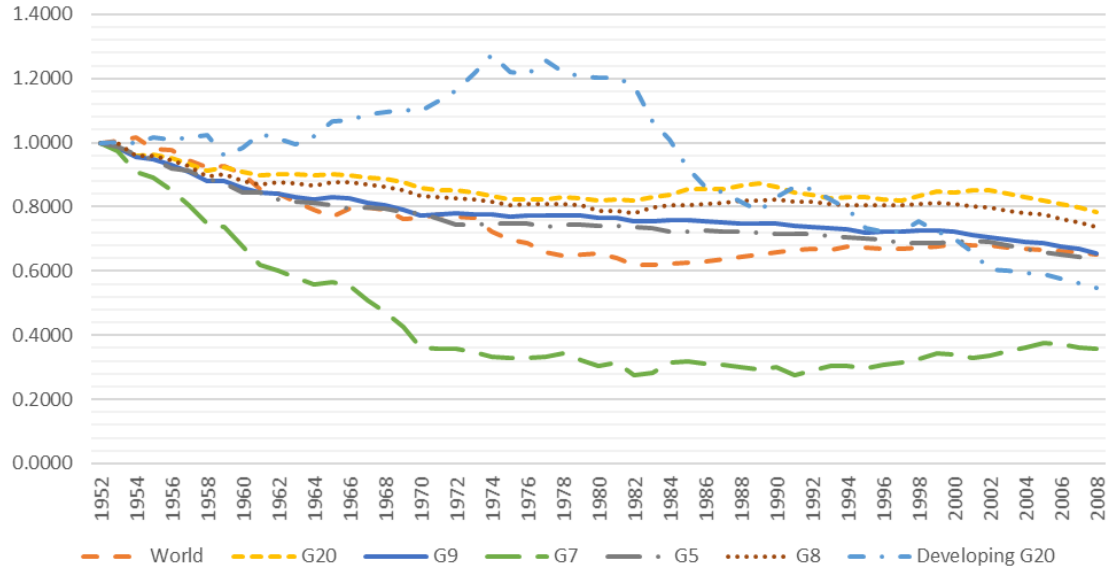


Figure 1: Sigma Sensitivity Analysis

While there has been a clear decline in sigma for all samples, including the comprehensive world sample, which is considered evidence of convergence over time, the effect is *far* less pronounced than the decline in sigma observed in the G7 and "Developing G20" samples. These samples contain countries that are far more homogenous in terms of both levels of per capita GDP and growth of per capita GDP across the sample. Rather than comparing "apples to oranges," comparison within more similar income groups seems to suggest convergence may be occurring more rapidly within like aggregate selections than between countries overall. To further test this claim, I attend to the World Bank Group typologies used by Boyle and McCarthy (1999) note, (updated with reclassifications of countries since the initial analysis is over 20 years old). This provides a more direct illustration of convergence occurring within countries with like per capita GDP per the World Bank Group typologies.

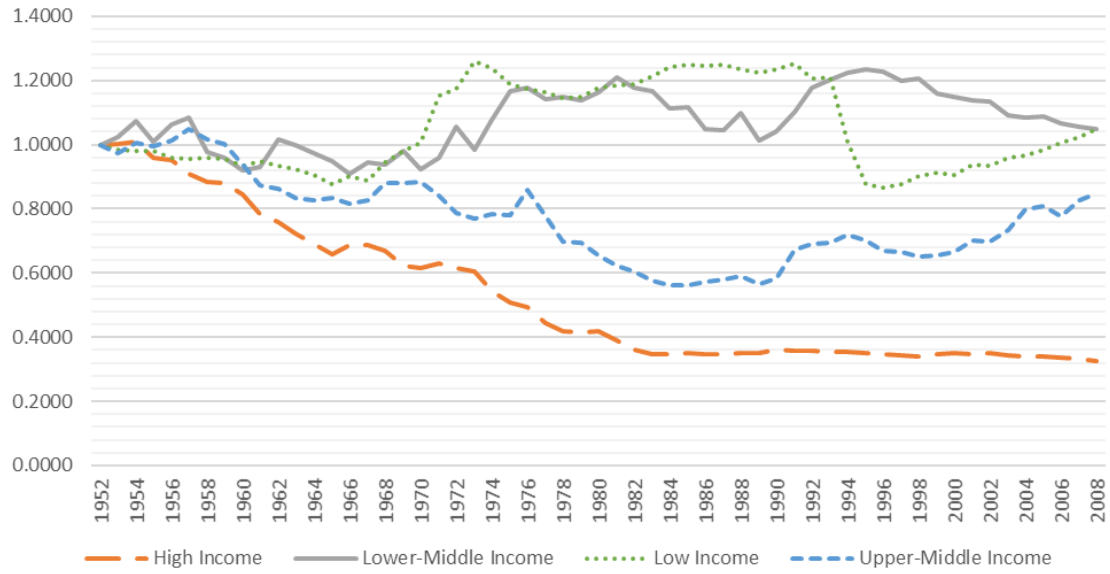


Figure 2: Sigma Sensitivity Analysis (WBG Classifications)

The results are striking, and imply that convergence may be far more sensitive to country selection than suggested in the groupings above. While we observe a clear decline in sigma for the

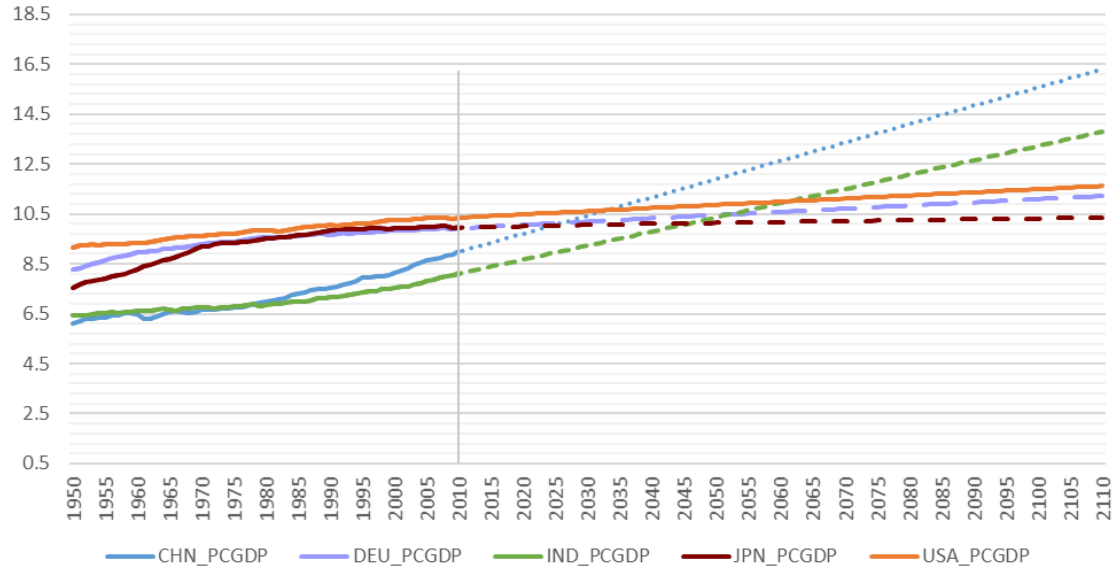


Figure 3: VAR(1) G5 Log Per Capita GDP Growth Forecasts - 1950-2110

high-income countries (on average, -1.6% for the sample with drops of 14% and 16% in the 1980s), the same cannot be said for any of the other three groupings. While there is a decline observed through 1990 for the upper-middle-income countries, that trend has been largely reversed since, through sigma is lower than was observed at the beginning of the sample. Even more troubling are the trends of the lower-middle and low-income country groupings. The sigma measures for these groups imply *divergence* over the sample, rather than convergence. The quality of institutions may be to blame for these results, particularly in the low-income grouping, but does cast doubt on the trend of convergence overall. More than anything, the results from the sigma analysis demonstrate the degree to which convergence is *highly* sensitive to country selection. While the results from the world sample do imply that convergence has occurred over the past half-century, it does not provide evidence to suggest that convergence is occurring unilaterally. The results from the income grouping sigma analysis suggests that, in fact, convergence in the "world" sample may be largely driven by a small selection of countries while other, poorer countries (who we are most interested in observing convergence in) are diverging. I attend to this in greater detail below.

Attending to the results from the VAR approach, I focus primarily on the results from the G5 and G8 VAR specifications (all VAR forecasts are included in the Appendix, Figures A.8-A.20). It is immediately clear that the choice of base year has a profound impact on the resulting forecasts. In the G5 forecasts from the VAR(1), trends are largely linear. The United States, Germany, and Japan all exhibit growth, though just barely, while India and China are clearly forecasted to surpass the developed economies—specifically, both economies are forecasted to surpass the United States in 2062 and 2033, respectively. In order to assess the sensitivity of results to changes in lag structure, I utilize a VAR(3). Three lags are chosen per the AIC criteria, which consistently implies a VAR(3) is the best fit, while the SIC criteria consistently picks the VAR(1). On one hand, results from the VAR(3) specification are very similar (see Appendix, Figure A.3), with China predicted to surpass the United States in 2033 and India in 2055. This lack of sensitivity to lag structure, however, does not hold across country groupings (as evidenced with the G8 grouping below).

Beyond forecasts, I include impulse responses to illustrate the behavior of countries' respective log real per capita GDP in response to shocks from *other* countries (see Appendix, Figures A.21-A.36). Each graph provides the *combined* responses of a given country's log real per capita GDP to unit shocks in *other* countries' log real per capita GDP over the course of 10 periods. This provides a graphical substitute for raw VAR output which tracks the response functions for GDP growth when it is considered in this highly interdependent context. Much like the results developed in the VAR forecasts, tying together a cohesive narrative about the behavior of countries' GDP growth to counterpart shocks is challenging with such dramatic sensitivity to changes in assumptions. Generally, the impulse responses across all specifications are well behaved and, given a long enough time horizon, tend to 0, thought the behavior of country's log per capita GDP differs.

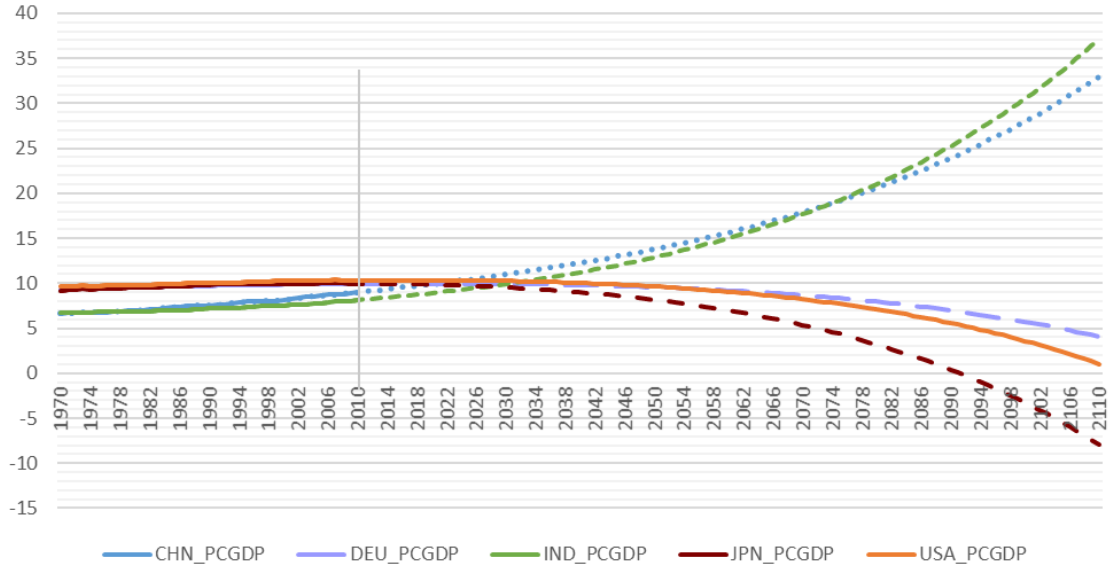


Figure 4: VAR(1) G5 Log Per Capita Growth Forecasts - 1970-2110

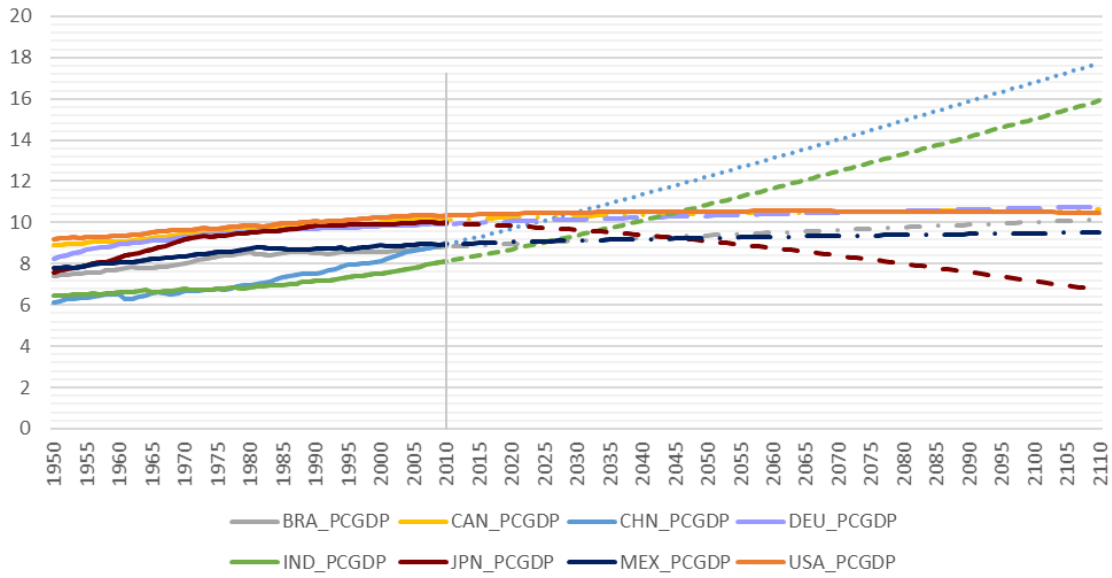


Figure 5: VAR(1) G8 Log Per Capita GDP Growth Forecasts - 1950-2110

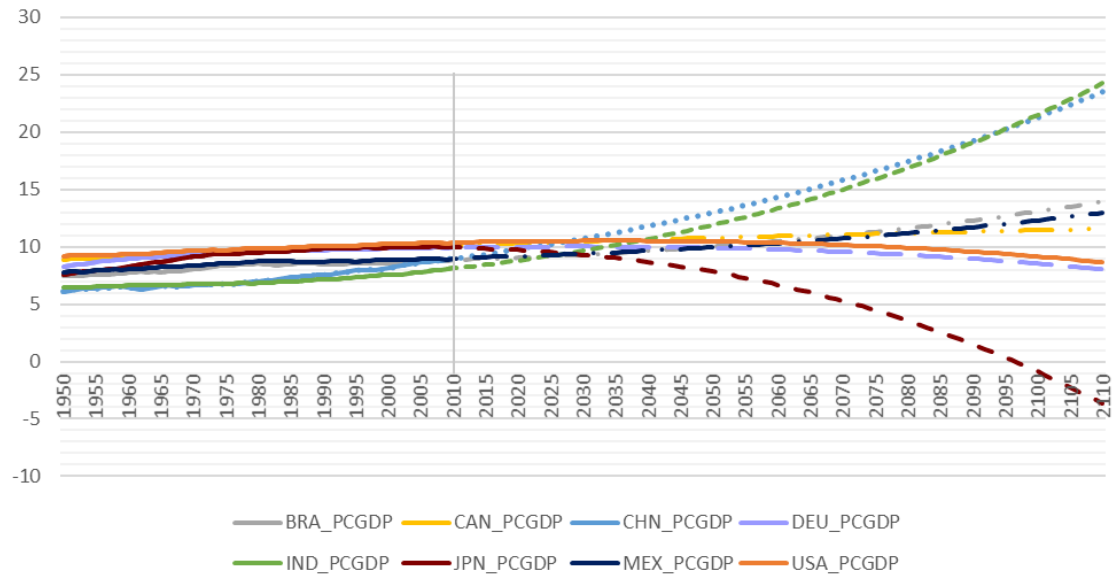


Figure 6: VAR(3) G8 Log Per Capita GDP Growth Forecasts - 1950-2110

Altering the country grouping, much like the base year changes above, exhibits dramatic impacts on the overall trend of the forecasts. On the other hand, the results are extremely sensitive to the base year for estimation. This is an intuitively sound finding: removing 20 years from the sample places more weight on realizations of growth in a more recent time frame. In turn, this captures more of the slower growth that has been exhibited in the developed economies in recent decades (and removes post-war reconstruction from the sample), and more of the rapid growth that has been exhibited by India and China. As such, forecasts for the United States, Germany, and Japan suggest that growth will slow dramatically through 2110, with growth going negative in Japan and forecasted to go negative in the other developed economies. Conversely, China is forecasted to surpass the United States growth in 2025 and India is forecasted to surpass the United States growth in 2032. Unlike the VAR(1) specification, changing specification for the 1970 base year does exhibit changes in scale—while predicted convergence years are largely consistent, the pace at which growth occurs differs greatly between specifications. The forecasted growth based on this specification, however, evolves almost exponentially over the course of the 100-year forecast. This growth forecast is likely unrealistic, as growth at this pace seems highly unsustainable for this span of time, particularly with such a steep growth curve. As such, I place more emphasis on the results of the 1950 base year forecasts.

For the VAR(1), I observe similar forecasts for growth and convergence as illustrated in the G5—India is forecasted to surpass the United States in 2046 while China is forecasted to surpass the United States in 2030. Unlike the G5 grouping, results are consistent between the 1950 base year forecasts and 1970 base year forecasts (see Appendix, Figure A.14). Unlike the G5 grouping, however, Japan's growth is predicted to slow, rather than remain stagnant at roughly 2010 levels. In stark contrast to the constancy of results across specification for the G5 grouping, using the VAR(3) with the same base year for forecasts, growth is predicted to slow (and ultimately go negative) in the developed economies of Japan, United States and Germany, growth is predicted to remain relatively stagnant in Canada, while Mexico, China, India, and Brazil are all forecasted to converge and surpass the developed economies. These results seem to echo more directly the results of the 1970 results above. Specifically, dates at which this convergence takes place are forecasted to occur in 2028, 2039, 2058, and 2060 for China, India, Brazil and Mexico, respectively. Results are comparable for the 1970 base year VAR(3) forecasts (see Appendix, Figure A.15), though magnitudes are greater in this estimation. Further, the forecasted trends for growth exhibit the same exponential behavior as the G5 grouping with 1970 base years. Impulse responses are included in the appendix to serve as a substitute for raw output, though the dramatic differences observed in these shocks makes the development of a cohesive narrative difficult, particularly with additional countries included. Further, given the high degree of subjectivity for impulse ordering, I have opted to pursue residual non-factorized impulse responses as opposed to Cholesky responses for

the larger country groupings—more research is appropriate to better understanding the process by which shocks progress through the global economy.

The dramatic differences evident in these results imply that, not only are the forecasts and VAR estimations highly sensitive to changes in assumptions, the way in which those changes manifest depends greatly on the country grouping. For instance, use of the different base year produces dramatically different results in the G5 grouping, while the lag structure produces no major change. Conversely, in the G8 grouping, use of the different base year elicits little change, while changes in specification create significantly different forecasts. The same dramatic differences in results are demonstrated in G9 forecasts (see Appendix, Figures A.16-A.20), going so far as to generate results that are a direct affront to those demonstrated in the aforementioned country groupings (i.e. explosive growth for Japan in the G9, VAR(3), 1950 base year sample). Given the lack of any real pattern in the results, I defer chiefly to the VAR(1), full sample specifications which remain relatively consistent across countries and predict the same general trends wherein developing countries converge to and then surpass developed countries and developed countries maintain growth, though at lackluster rates (with the unique exception of Japan). To provide further evidence of this supposition, I conduct forecasts of the VAR(1) for the full G20 (excluding Russia due to a lack of data). These forecasts, for the 1950 base year, imply China, India, Brazil, South Korea, Indonesia, and Australia will eventually surpass the United States, while other countries like Turkey and Argentina will converge to the United States log real per capita GDP by 2110. Given the size of the VAR(1) used for this estimation, I do not include impulse responses (to do so would be unwieldy and not informative), and use the forecasts primarily to illustrate the broader trend of convergence observed in forecasts.

# 4 Conclusion

Utilizing the Maddison Project's dataset for real per capita GDP (in 1990 Geary-Khamis International Dollars to account for measurement comparability), I find evidence of convergence from both the sigma methodology and VAR methodology as detailed above. While, the results of both approaches are broadly consistent with convergence, the pace/behavior of that convergence over the past half-century (as evidenced in the sigma approach) and the predictions for convergence in the future (as evidenced in VAR specification forecasts), are *highly* sensitive to changes in assumptions.

The results of the sigma methodology suggest that, overall, convergence has occurred over the past half-century. The degree to which we observe convergence using this measure, however, is extremely susceptible to the country grouping. For instance, we observe dramatic convergence taking place in high-income countries, with divergence taking place in the poorest countries. Given the trend of the developing G20 group, which includes a mix of low-middle- and upper-middle-income countries, I posit that there seems to be a certain level of development necessary to observe convergence. The countries in this group have observed remarkable growth over the past few decades (many are denominated as BRICS or emerging market economies) and seem to be more accurate representations of the catch-up effect. It is possible that the other countries in these lower-middle- and low-income groupings have not yet experienced the injection of capital necessary to incite the rapid productivity gains observed in these countries that have led to convergence. Further, I see these trends as a repudiation of "club convergence." There is little evidence in the sigma analysis to suggest that countries with like per-capita GDP levels, as classified by the World Bank Group, are converging within their income strata. Rather, convergence is being exhibited in high-income countries with well establishing markets and between these countries and emerging market economies which are already exhibiting rapid growth.

While the sigma approach provides an intuitive illustration of the trend of convergence given past data, it is limited in its application for predicting the path of per capita GDP growth in the future. If we observe convergence is occurring in the sigma methodology, when will it occur? The VAR specifications provide evidence that in those economies that have undergone their injection of capital and have been/are experiencing rapid productivity gains will converge to the developed economies in the selections in the next 50 years. Thus, based on the VAR approach, there is additional evidence that convergence is occurring and, therefore, predicted to occur over the course of the next century. Using the G20 selection, for instance, Indonesia, India, Brazil, China, and South Korea are all forecasted to surpass the log per capita GDPs of the other G20 countries. Further, in more parsimonious forecasts, developing economies (i.e. China, India, Mexico and Brazil) generally exhibit convergence over the course of the forecast. These results, however, much

like the sigma results, are remarkably sensitive to changes in assumptions. Furthermore, changes in assumptions do not exhibit consistent patterns. Changing country composition, for instance, exhibits significantly different forecasts between specifications and with regard to base years for forecasting. The lack of any real observable pattern makes it difficult to pick a "best" fit for the VAR with respect to assumptions, though the results of the VAR(1), 1950 base year forecasts are largely consistent across country groupings, so I emphasize the results from these forecasts in particular. Regardless, convergence is evidenced for developing G20 countries, in particular, through far more research and attention are needed to develop a more holistic understanding of convergence estimated through VARs.

As such, significant sensitivity of results to changes in assumptions, more research is appropriate to further pin down the most accurate illustration of convergence both past and future. Given the sensitivity, additional country groupings, lag structures, and time periods serve to further explore convergence behavior. Further, the more data that become available for this analysis, the richer the results will be, especially considering the high degree of sensitivity to the sampling period—capturing more of the behavior of per capita GDP from the past decade would provide more realistic forecasts and place more weight on the more recent realizations of these countries, particularly developing economies like India and China. One further limitation of the VAR forecasts, in particular, are the implicit findings that log per capita GDP in the developing economies predicted to surpass the United States and the like imply that the growth will continue rapidly ad infinitum. The catch-up effect, as detailed in the introduction, suggests that a certain level of development will be reached such that productivity gains exhibit diminishing marginal returns. At some point, these economies two will be unable to sustain the rapid growth they exhibit today and in the near-future. Developing forecasts that could model this behavior would be a remarkable contribution to the analysis, and would capture the behavior of convergence more robustly. It is easy to model the economies on increasing marginal returns side (China and India) and on the decreasing marginal returns side (United States and Japan), but far more difficult to model the transition these developing economies will make as growth slows. As such, more analysis is needed.

# A Figures

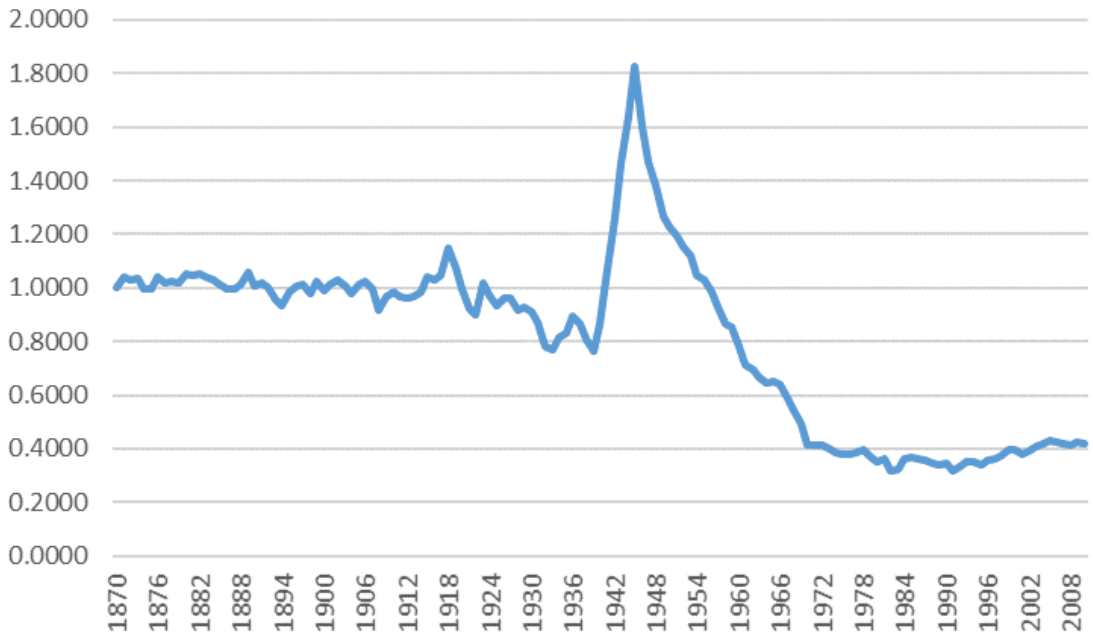


Figure A.7: G7 Sigma - 1870-2010

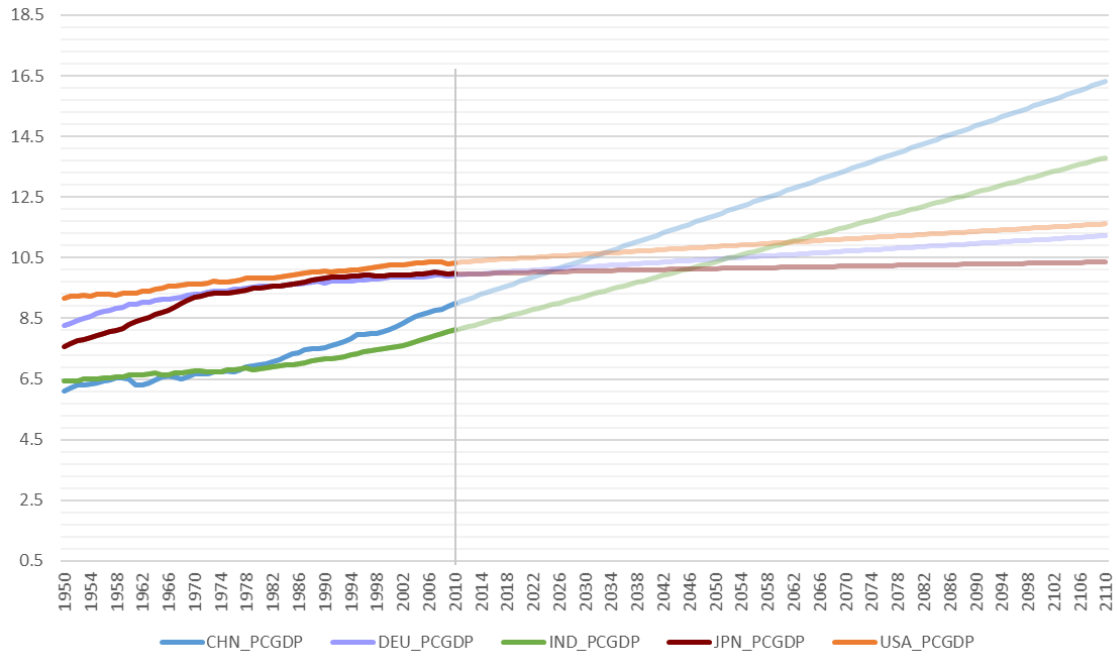


Figure A.8: VAR(1) G5 Log Per Capita GDP Growth Forecasts - 1950-2110

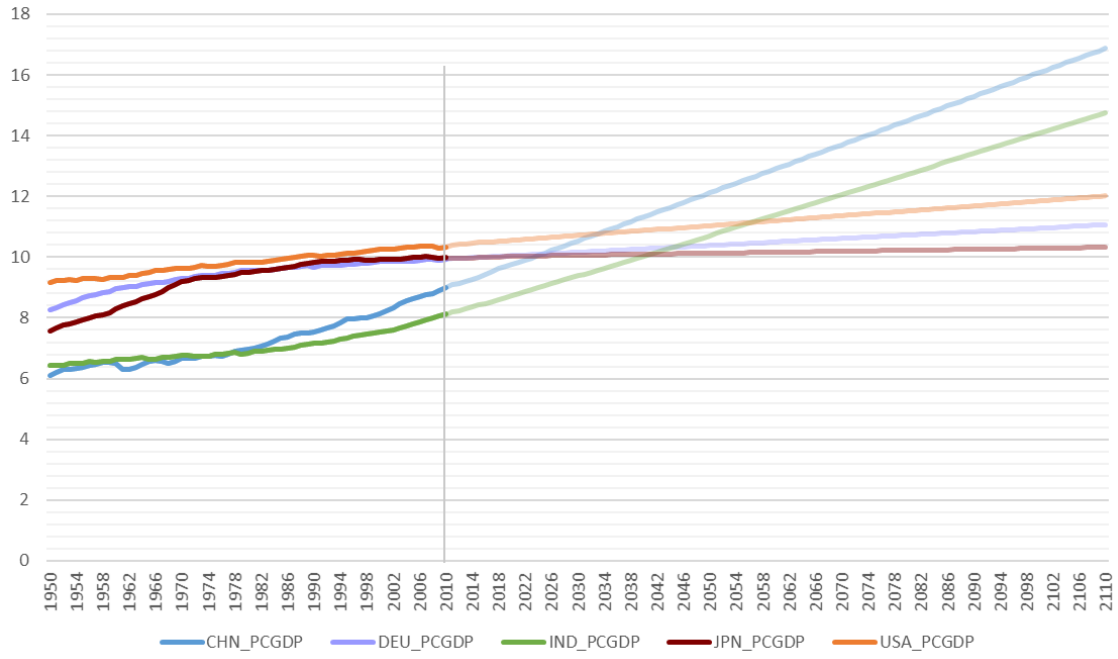


Figure A.9: VAR(3) G5 Log Per Capita Growth Forecasts - 1950-2110

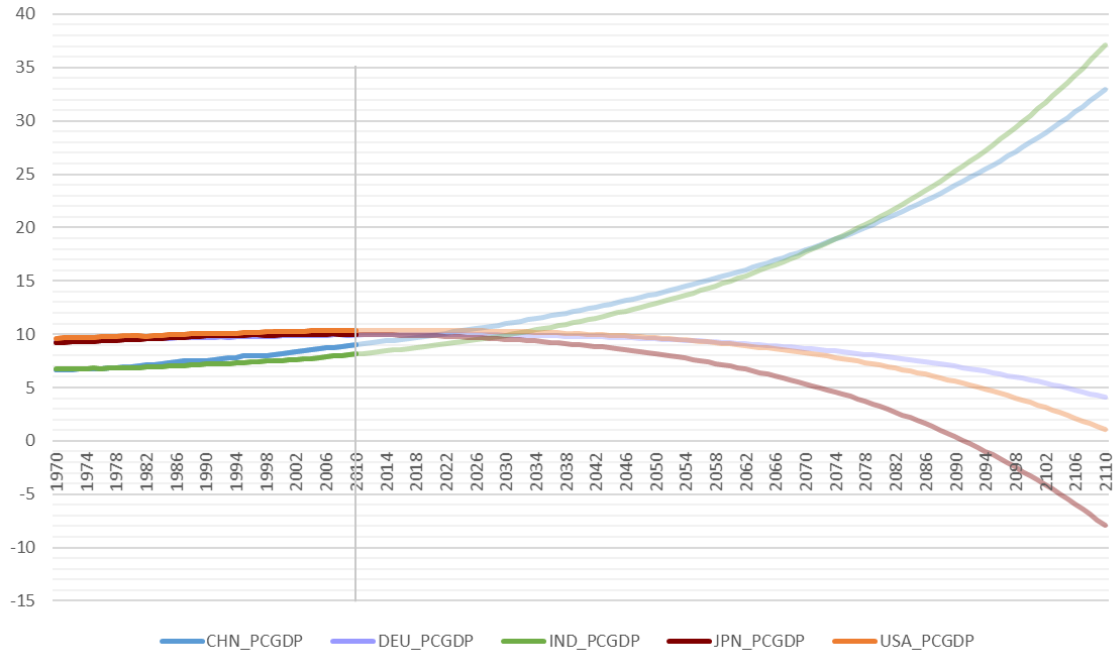


Figure A.10: VAR(1) G5 Log Per Capita Growth Forecasts - 1970-2110

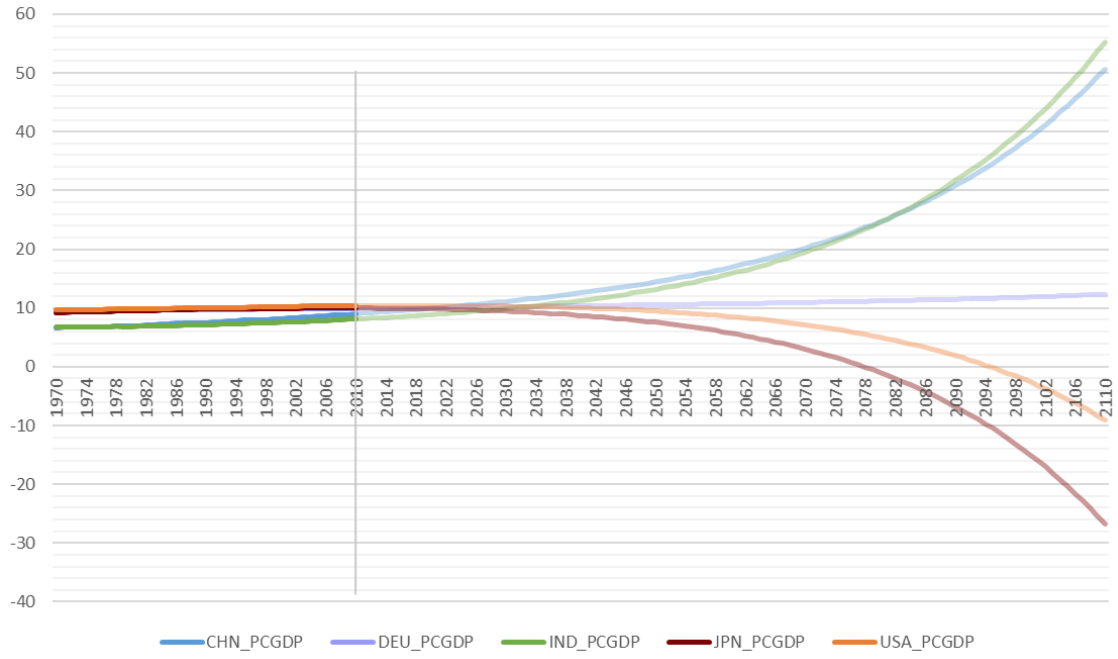


Figure A.11: VAR(3) G5 Log Per Capita Growth Forecasts - 1970-2110

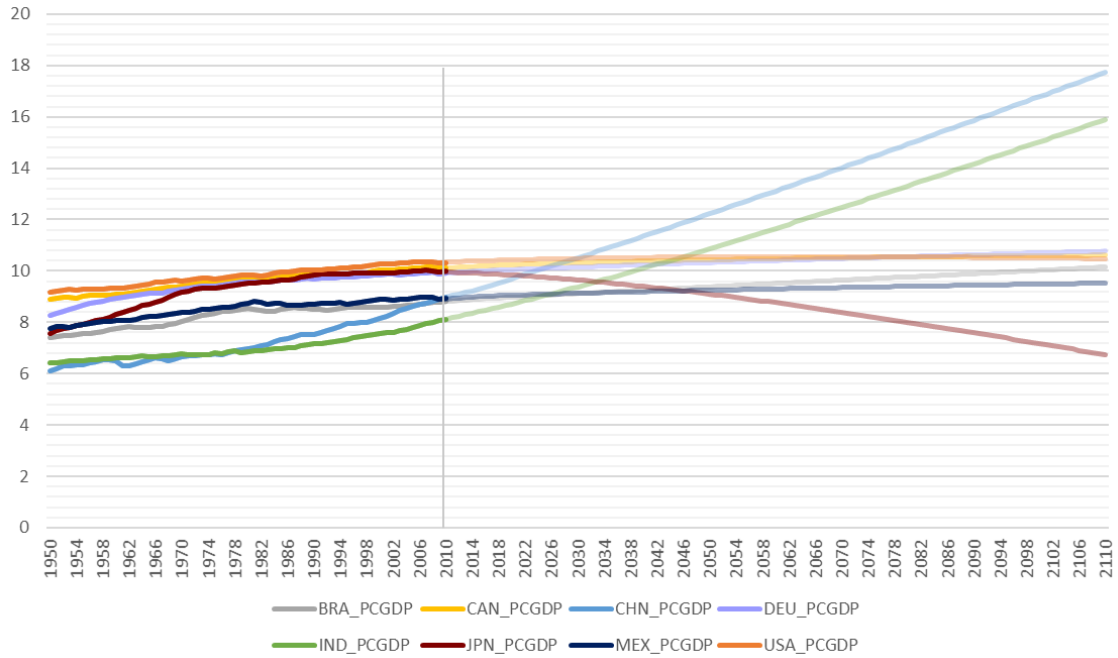


Figure A.12: VAR(1) G8 Log Per Capita GDP Growth Forecasts - 1950-2110

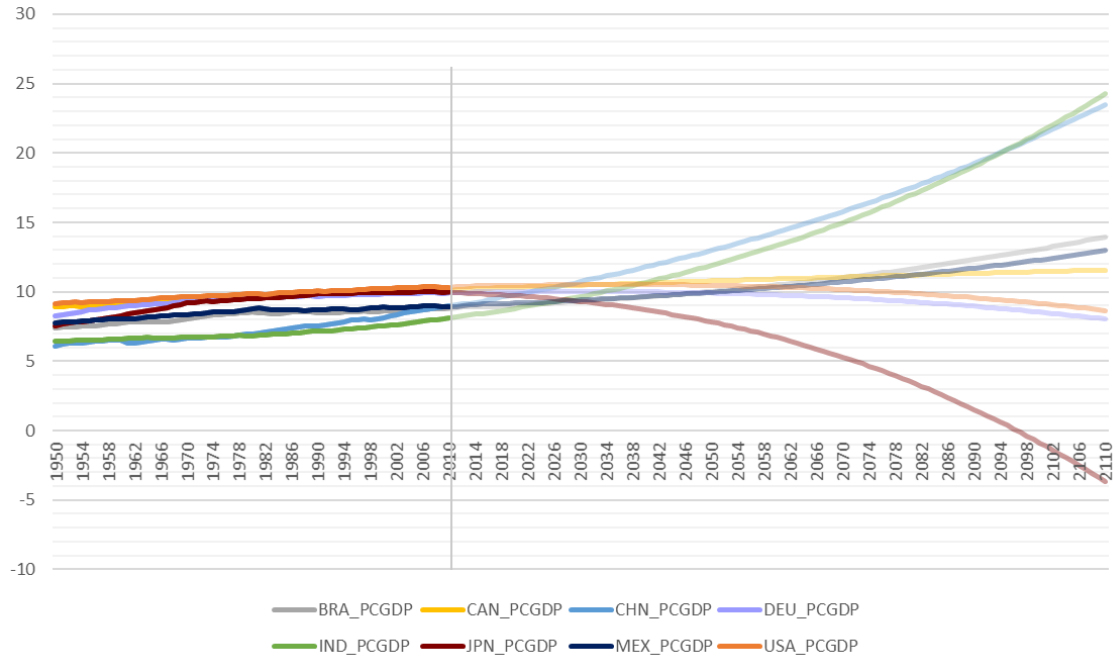


Figure A.13: VAR(3) G8 Log Per Capita GDP Growth Forecasts - 1950-2110

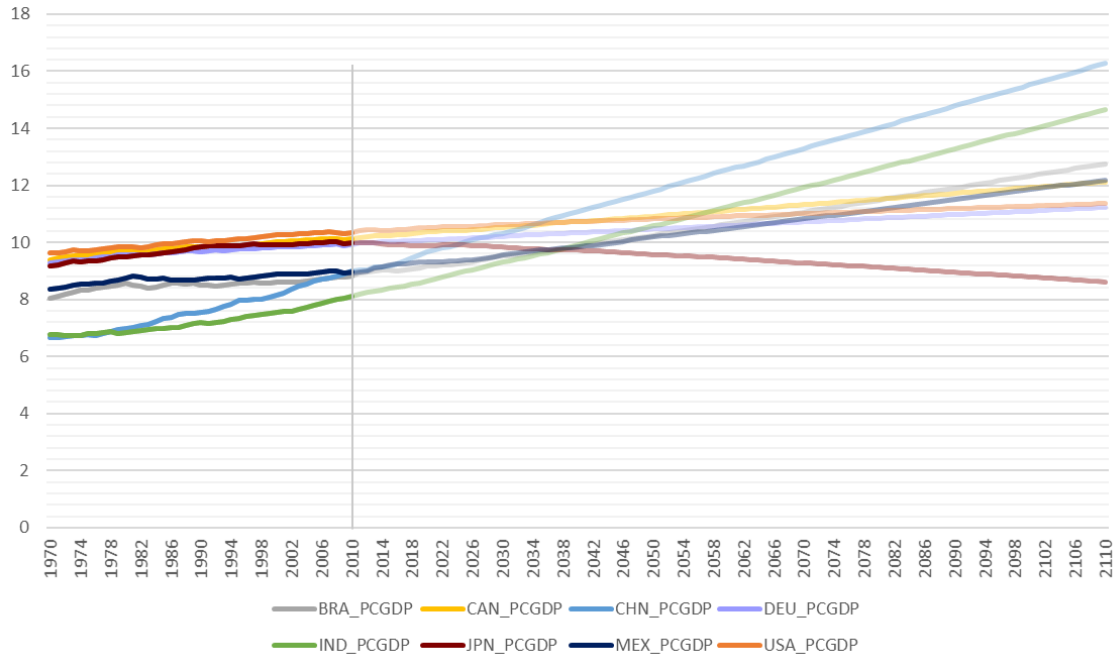


Figure A.14: VAR(1) G8 Log Per Capita GDP Growth Forecasts - 1970-2110

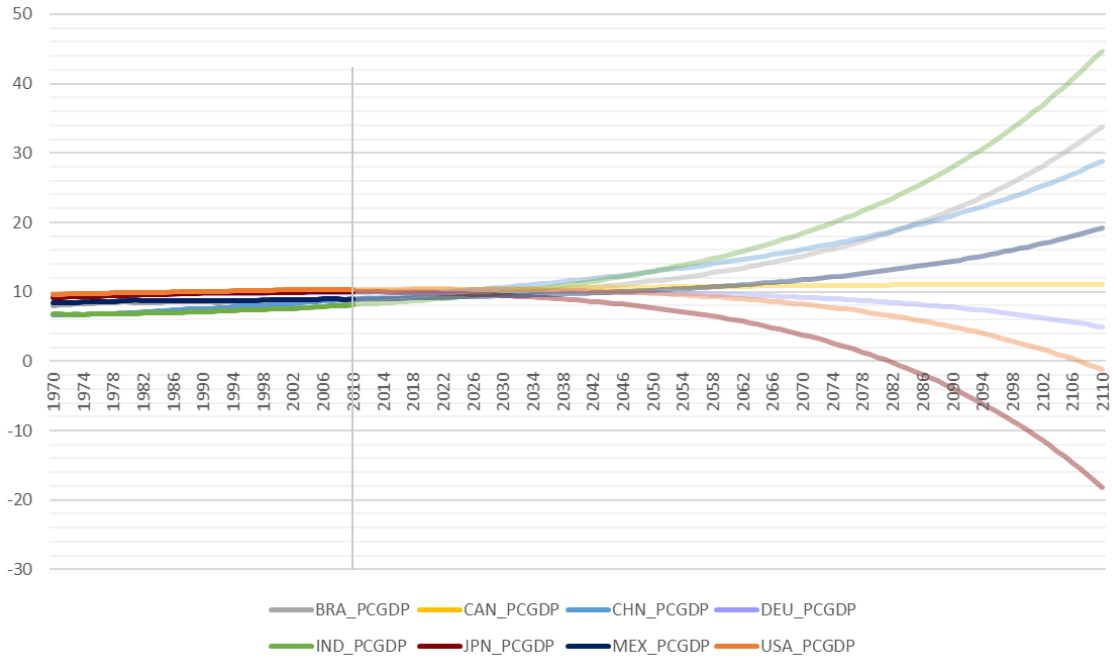


Figure A.15: VAR(3) G8 Log Per Capita GDP Growth Forecasts - 1970-2110

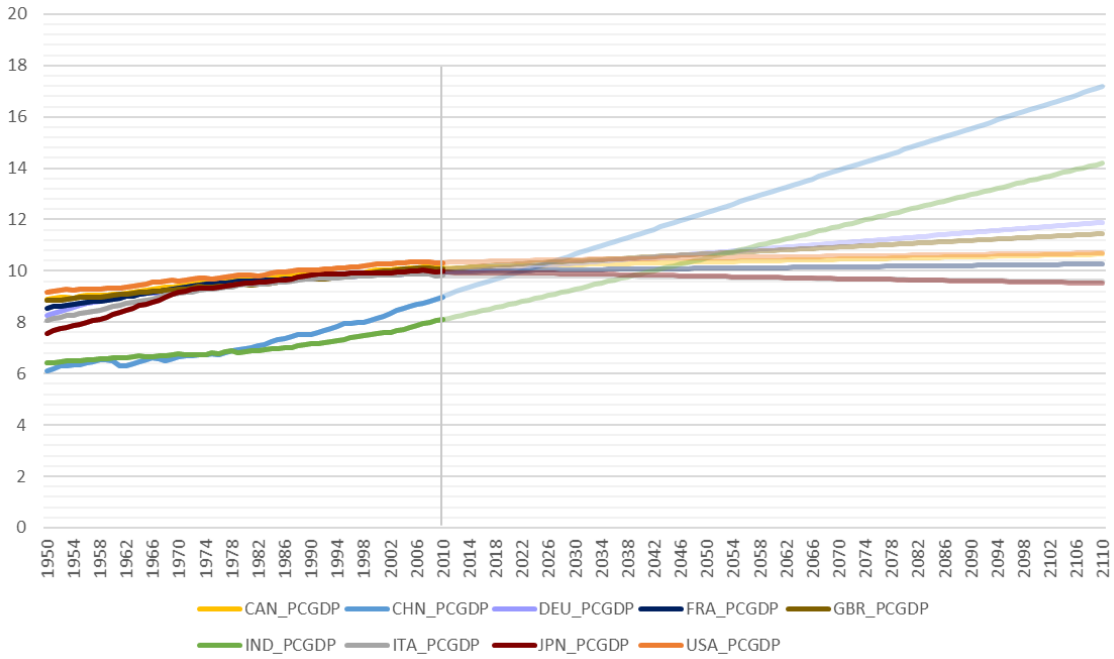


Figure A.16: VAR(1) G9 Log Per Capita GDP Growth Forecasts - 1950-2110

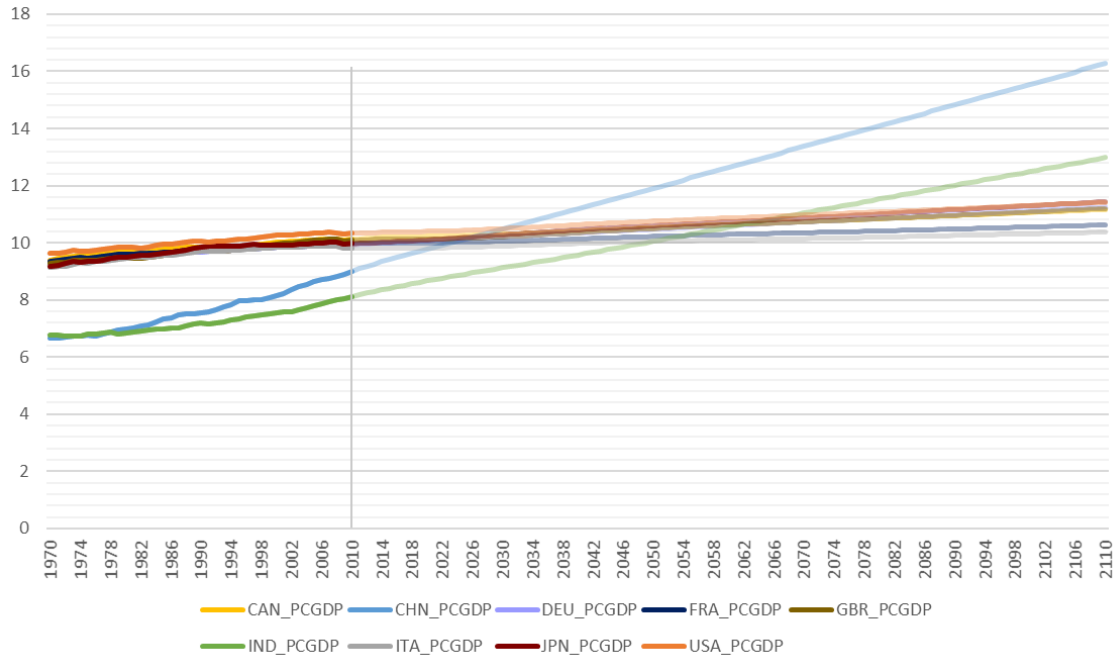


Figure A.17: VAR(1) G9 Log Per Capita GDP Growth Forecasts - 1970-2110

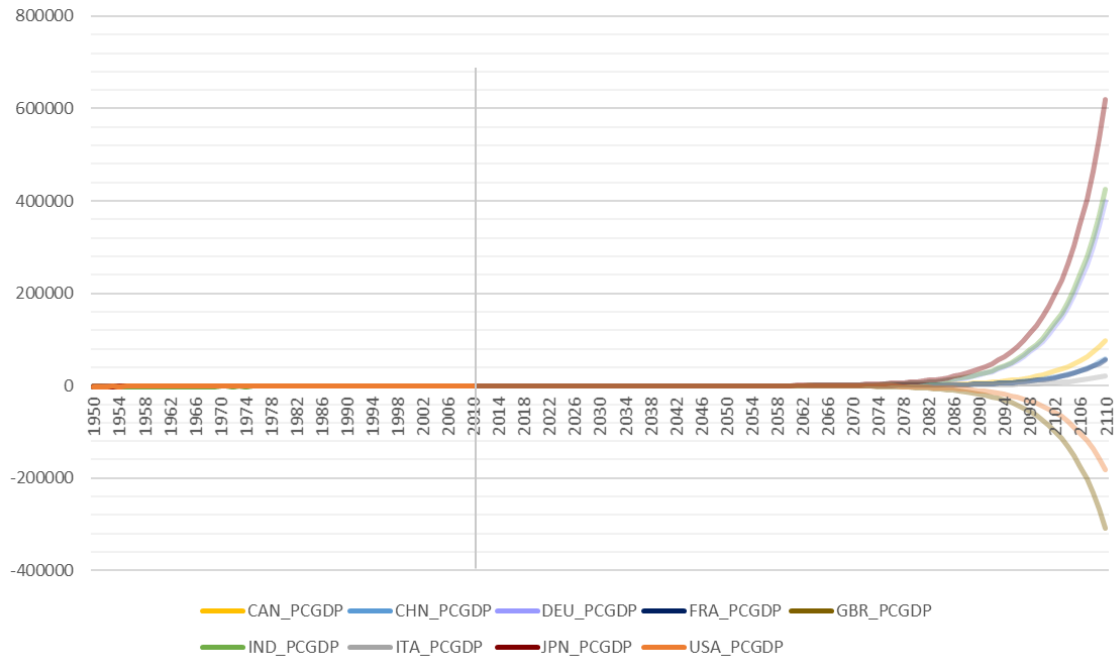


Figure A.18: VAR(3) G9 Log Per Capita GDP Growth Forecasts - 1950-2110

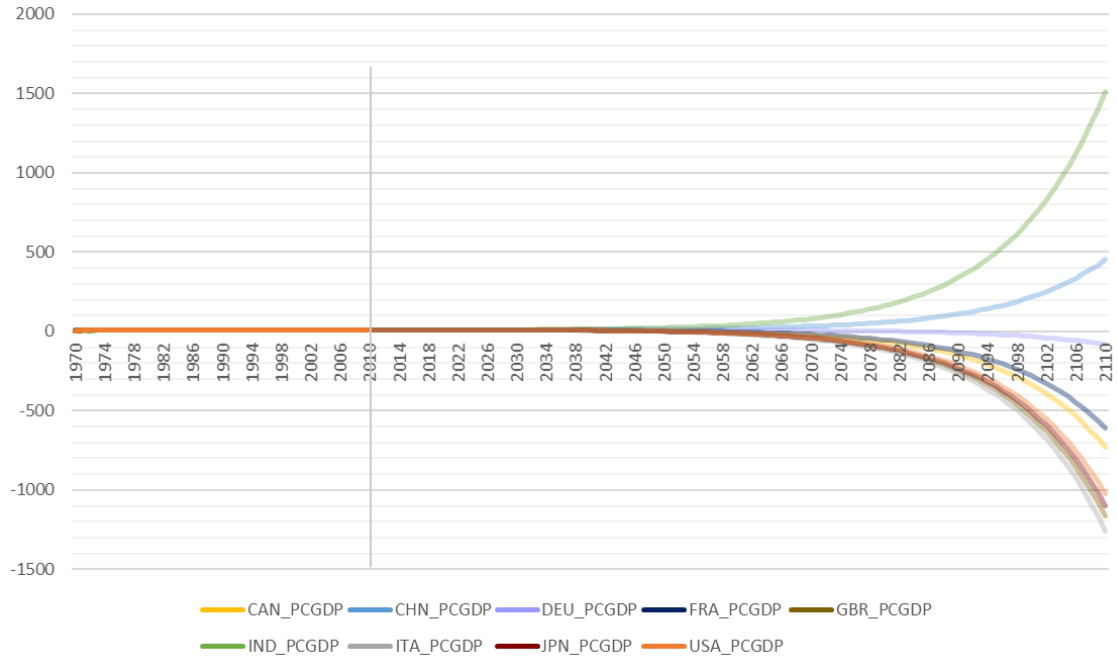


Figure A.19: VAR(3) G9 Log Per Capita GDP Growth Forecasts - 1970-2110

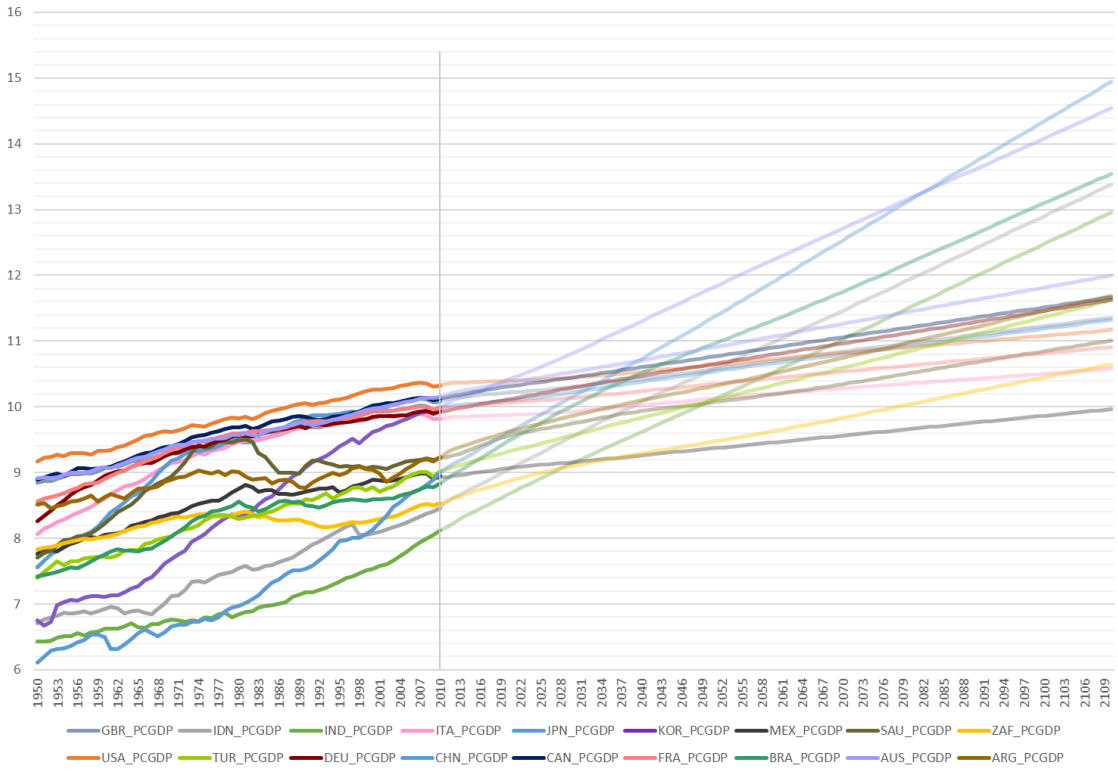


Figure A.20: VAR(1) G20 Log Per Capita GDP Growth Forecasts - 1950-2110

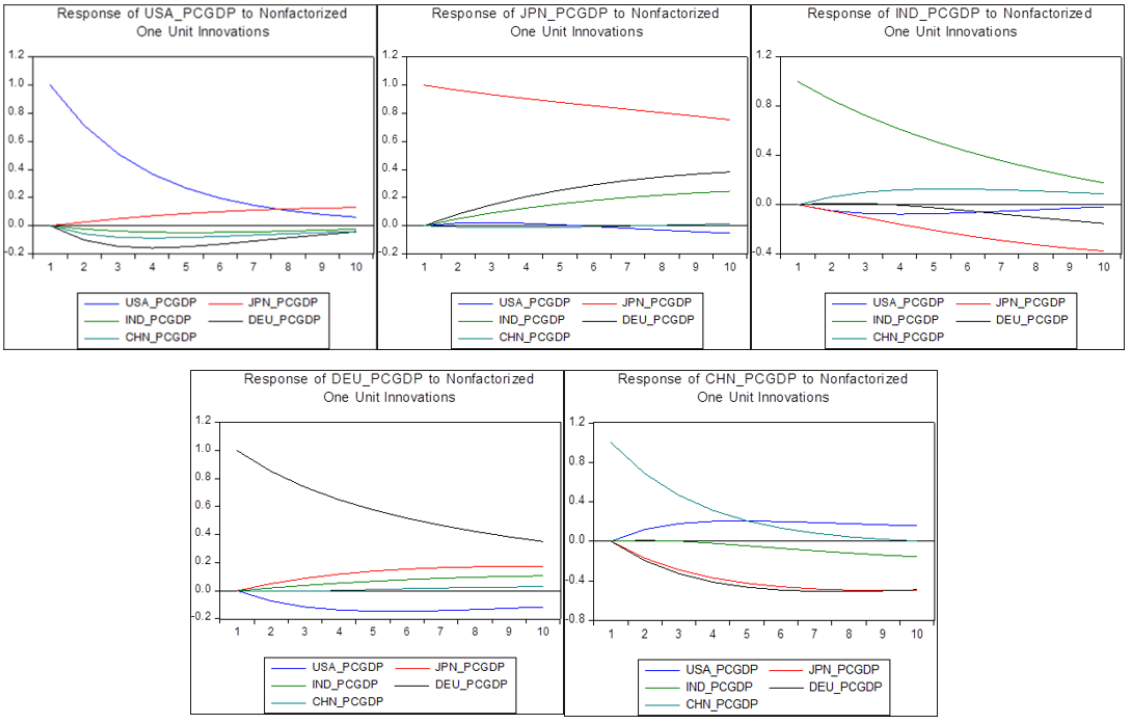


Figure A.21: Residual Impulse Responses for G5 VAR(1) – Combined Impulse Responses – 1950-2010 Sample

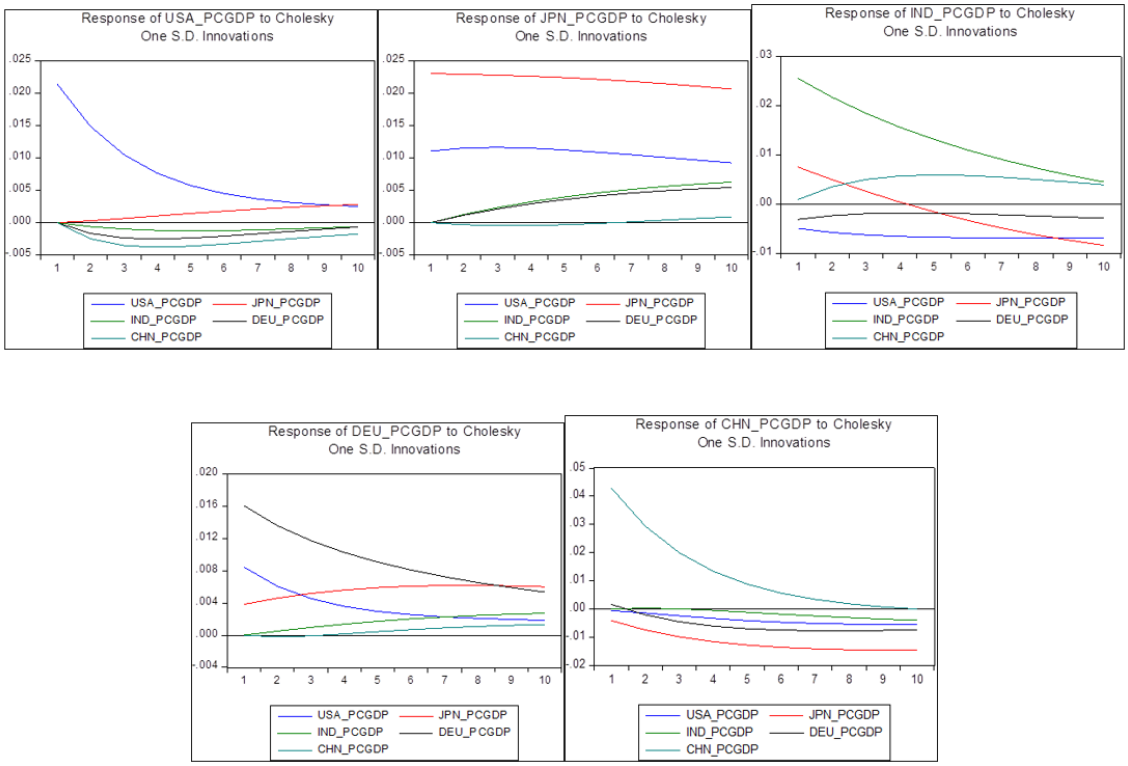


Figure A.22: Cholesky Impulse Responses for G5 VAR(1) – Combined Impulse Response – 1950-2010 Sample

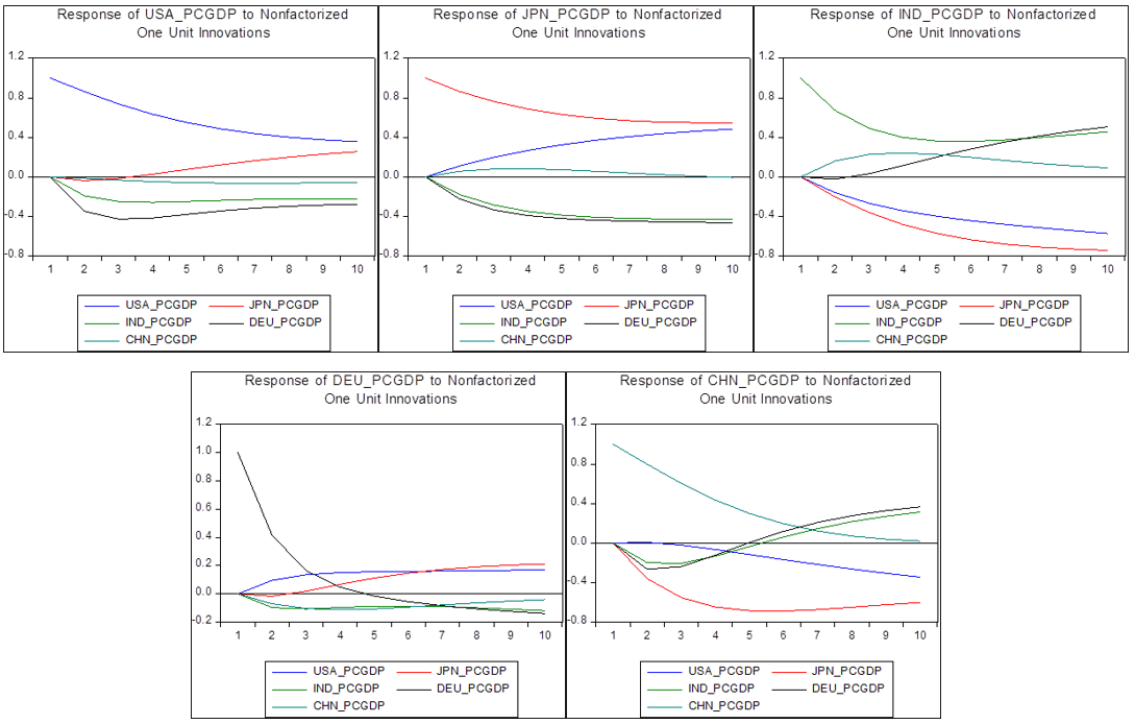


Figure A.23: Residual Impulse Responses for G5 VAR(1) – Combined Impulse Response – 1970-2010 Sample

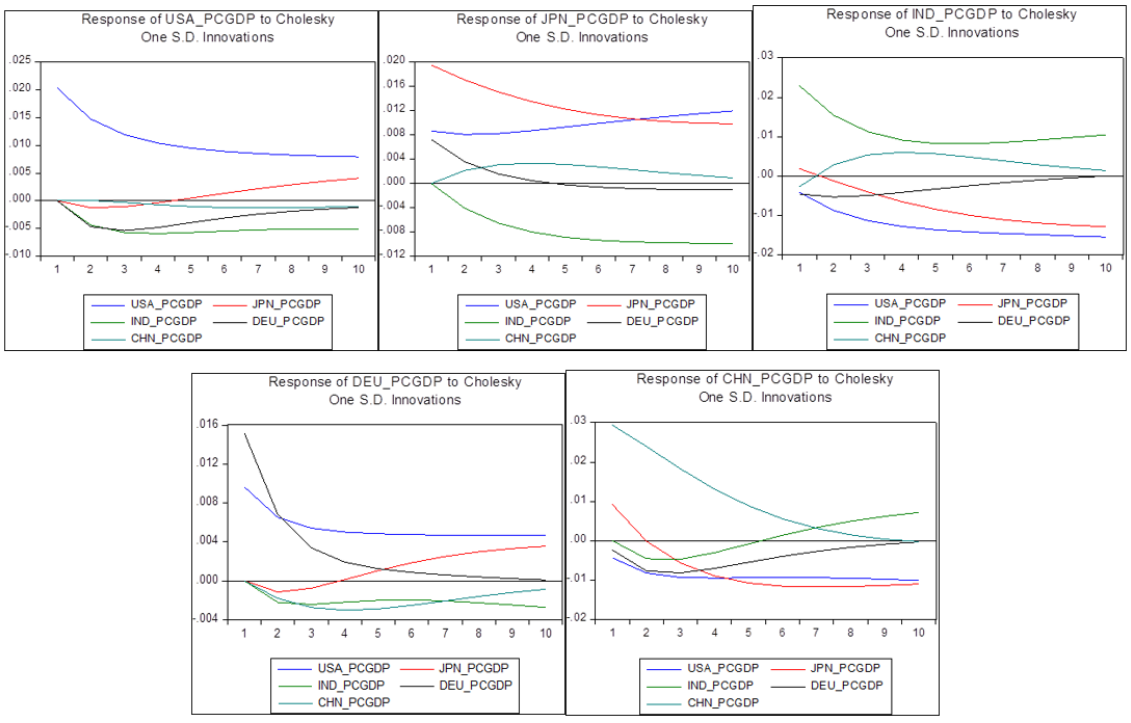


Figure A.24: Cholesky Impulse Responses for G5 VAR(1) – Combined Impulse Response – 1970-2010 Sample

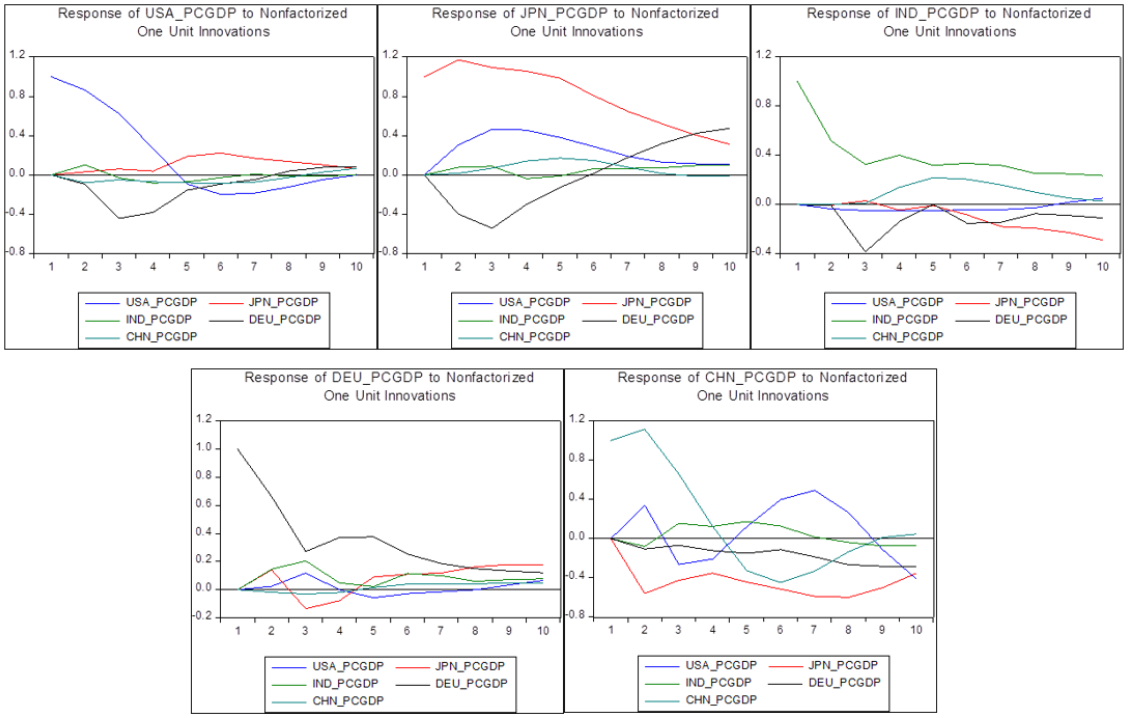


Figure A.25: Residual Impulse Responses for G5 VAR(3) – Combined Impulse Response – 1950-2010 Sample

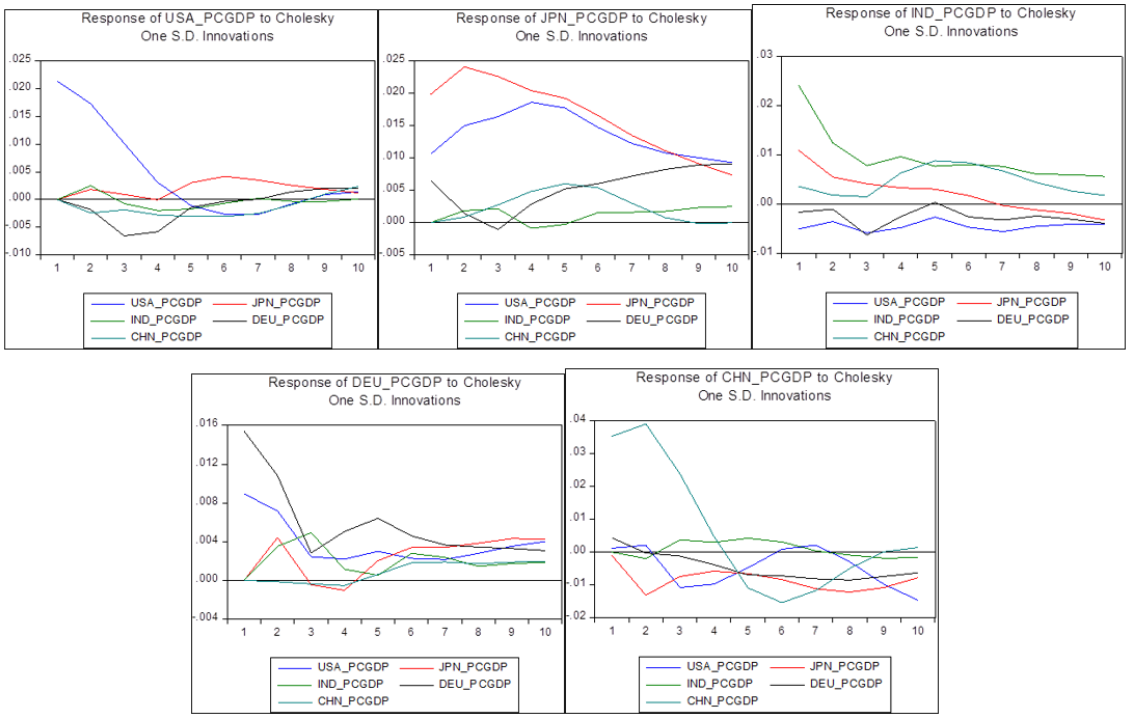


Figure A.26: Cholesky Impulse Responses for G5 VAR(3) – Combined Impulse Response – 1950-2010 Sample

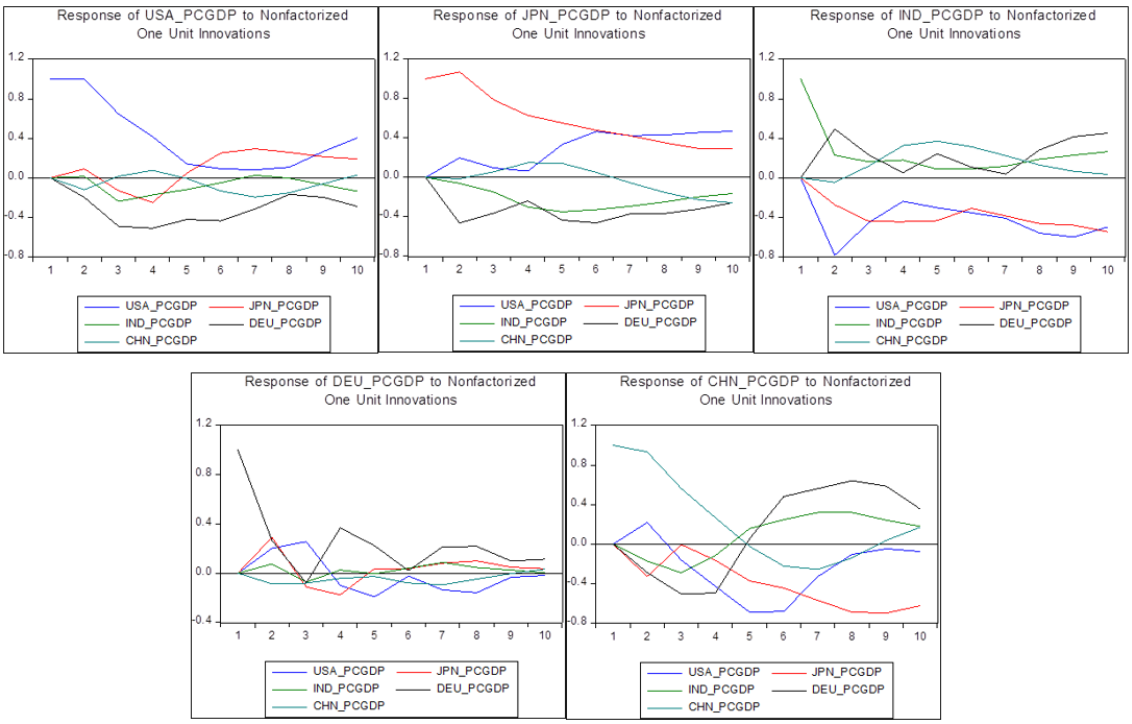


Figure A.27: Residual Impulse Responses for G5 VAR(3) – Combined Impulse Response – 1970-2010 Sample

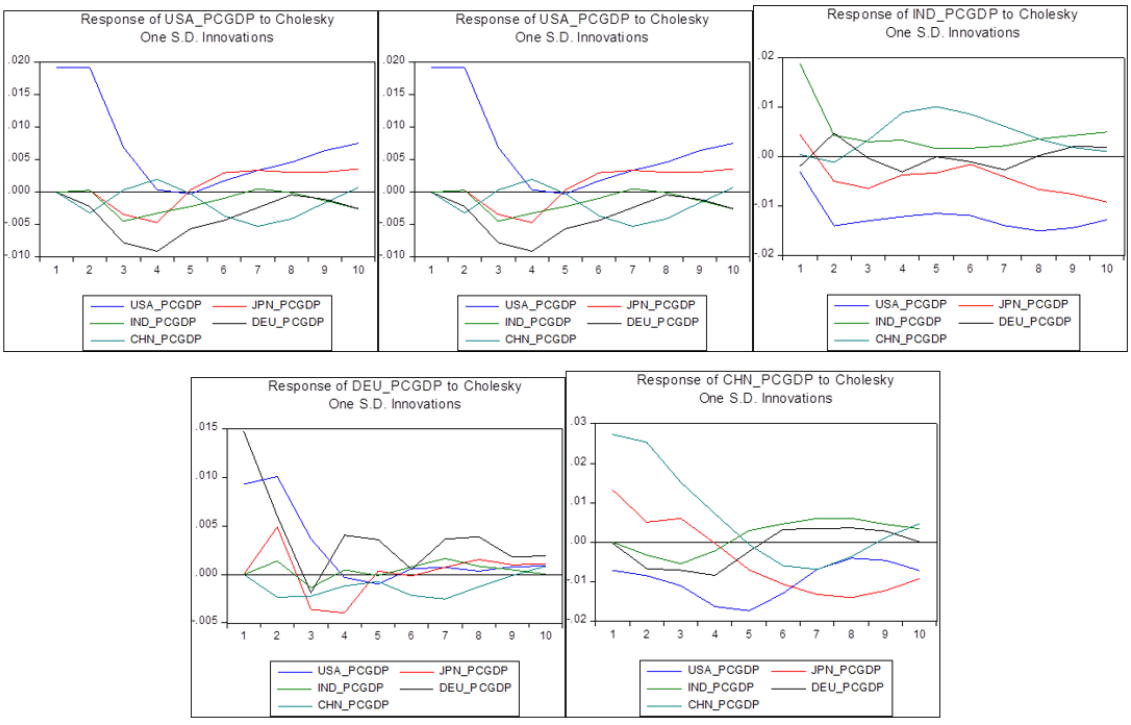


Figure A.28: Cholesky Impulse Responses for G5 VAR(3) – Combined Impulse Response – 1970-2010 Sample

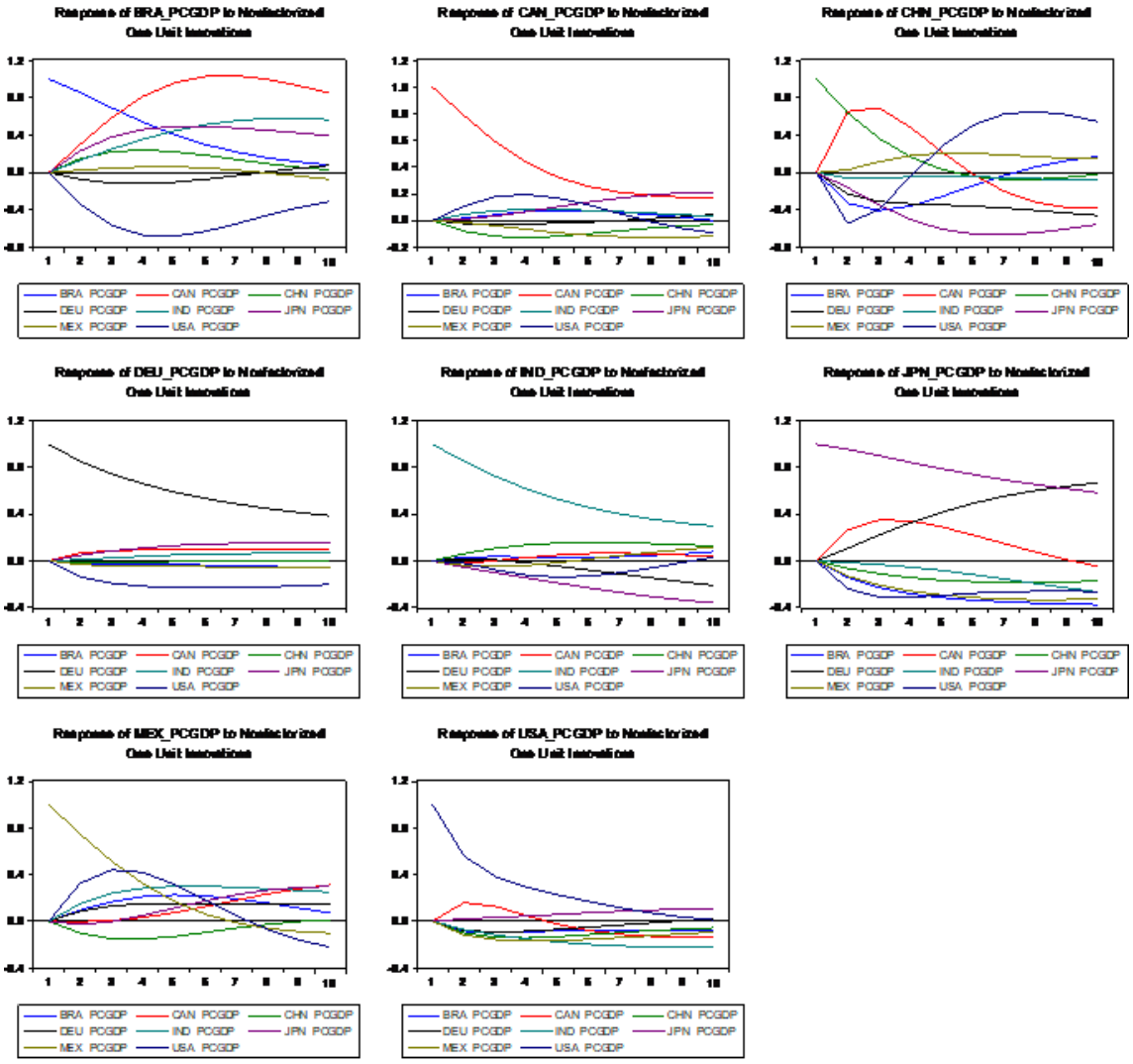


Figure A.29: Residual Impulse Responses for G8 VAR(1) – Combined Impulse Response – 1950-2010 Sample

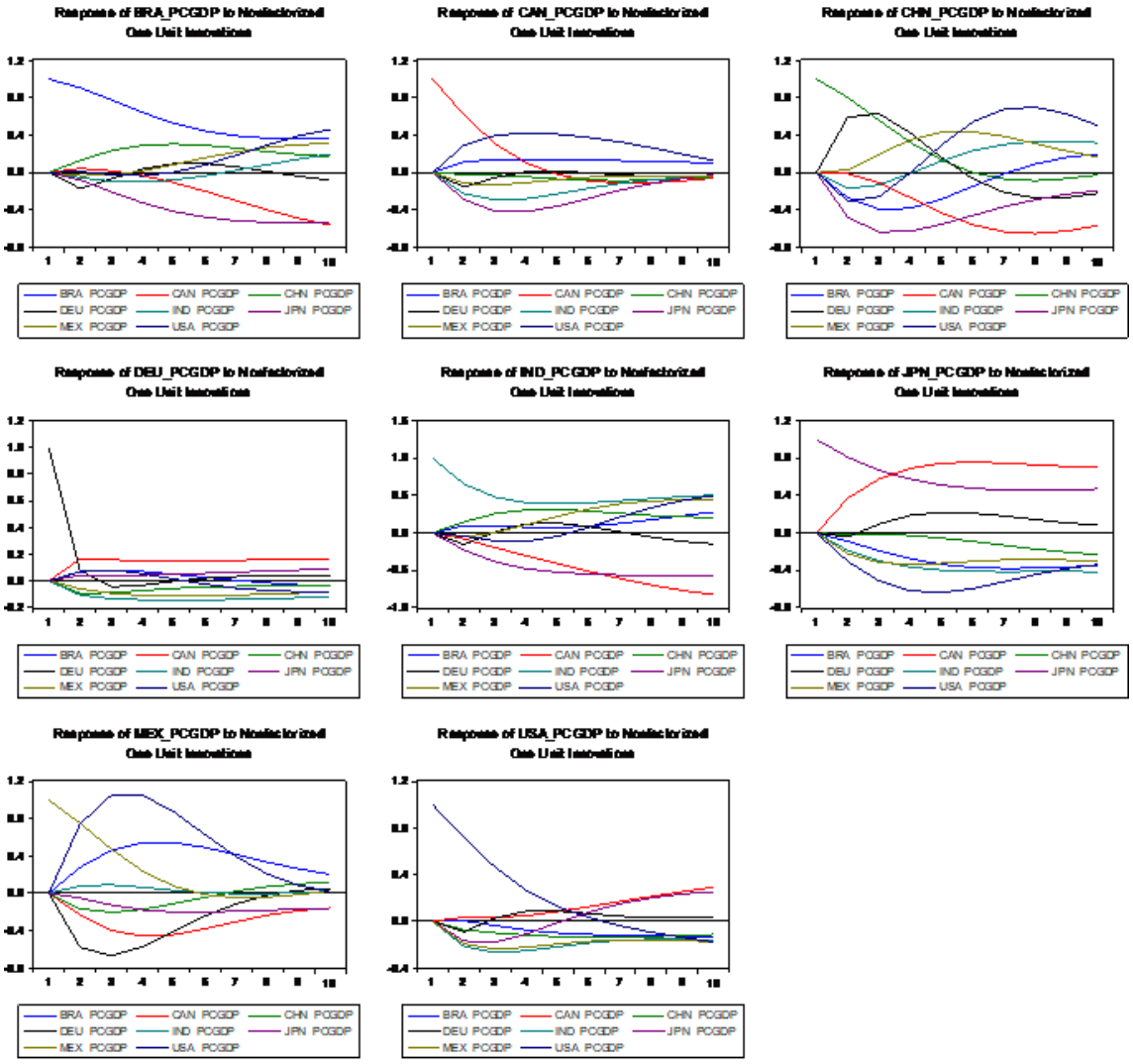


Figure A.30: Residual Impulse Responses for G8 VAR(1) – Combined Impulse Response – 1970-2010 Sample

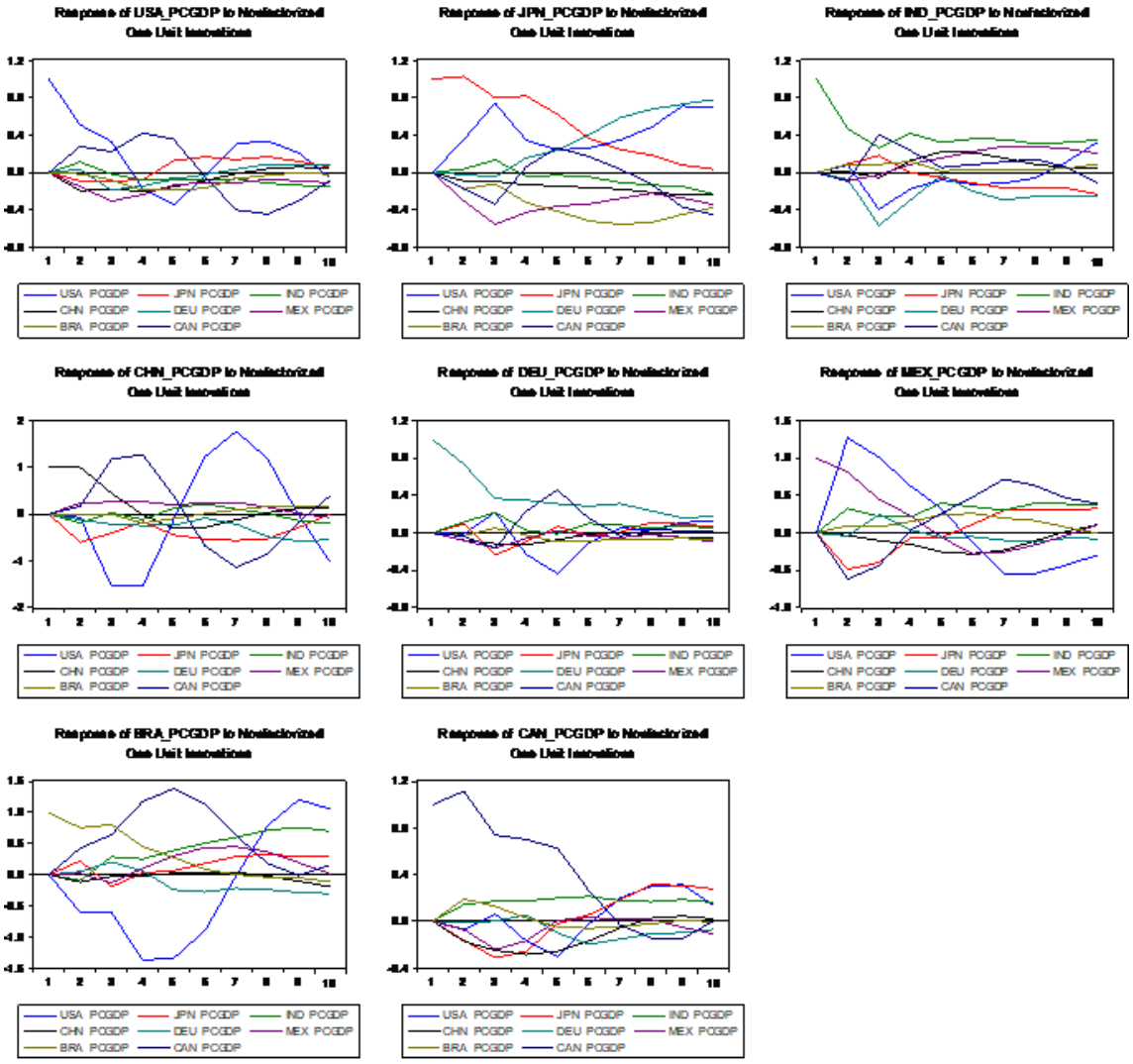


Figure A.31: Residual Impulse Responses for G8 VAR(3) – Combined Impulse Response – 1950-2010 Sample

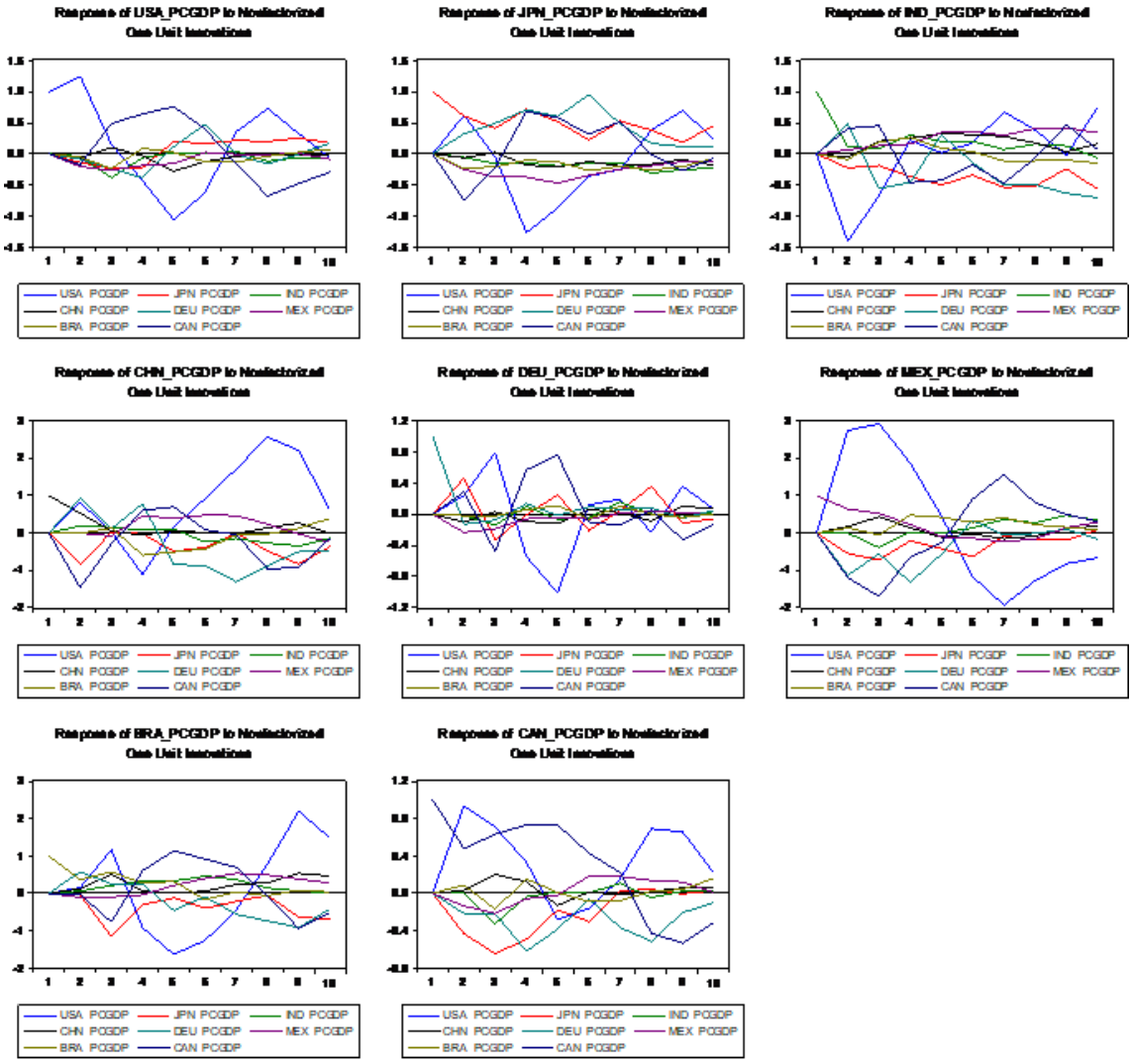


Figure A.32: Residual Impulse Responses for G8 VAR(3) – Combined Impulse Response – 1970-2010 Sample

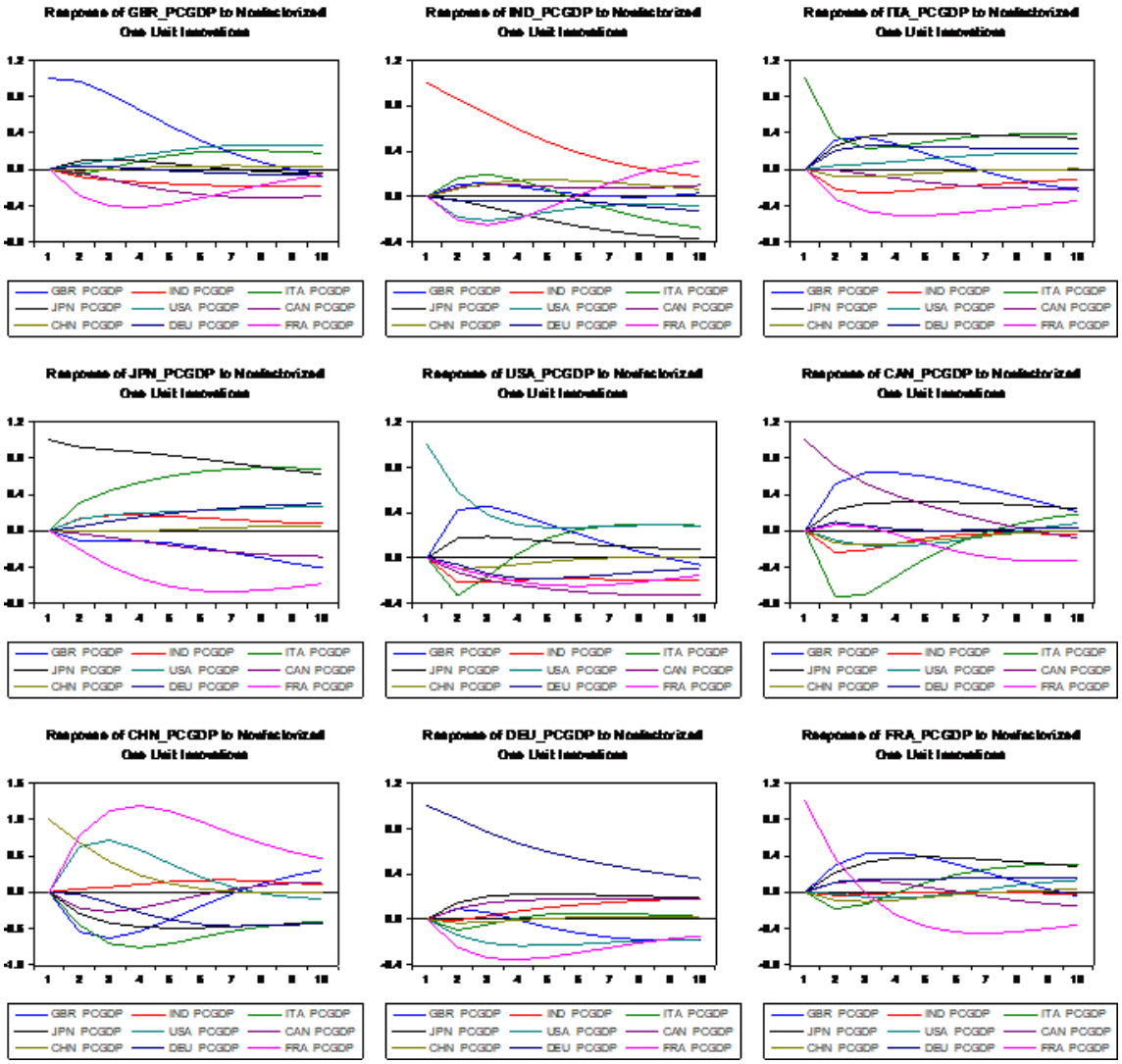


Figure A.33: Residual Impulse Responses for G9 VAR(1) – Combined Impulse Response – 1950-2010 Sample

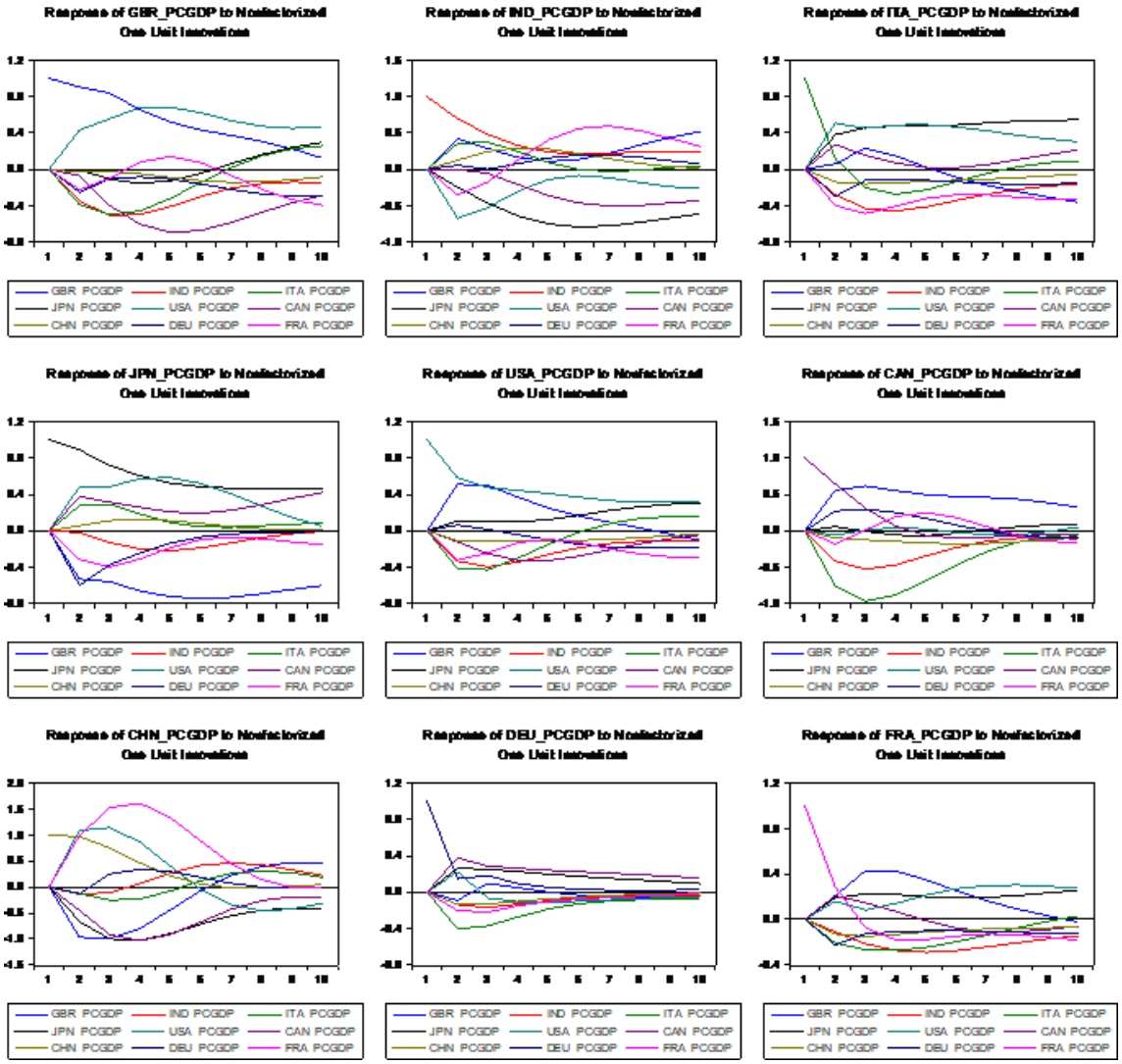


Figure A.34: Residual Impulse Responses for G9 VAR(1) – Combined Impulse Response – 1970-2010 Sample

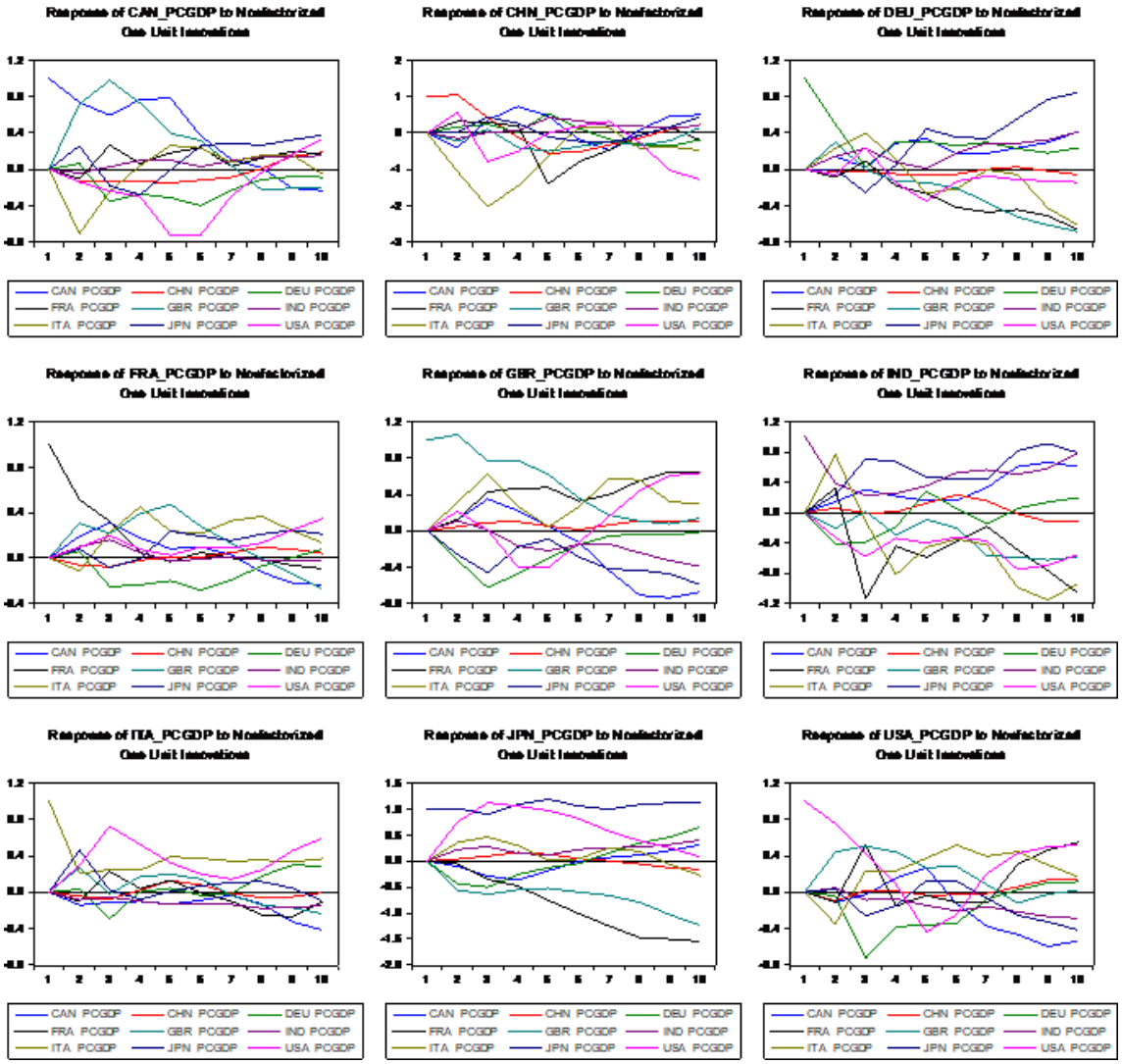


Figure A.35: Residual Impulse Responses for G9 VAR(3) – Combined Impulse Response - 1950-2010 Sample

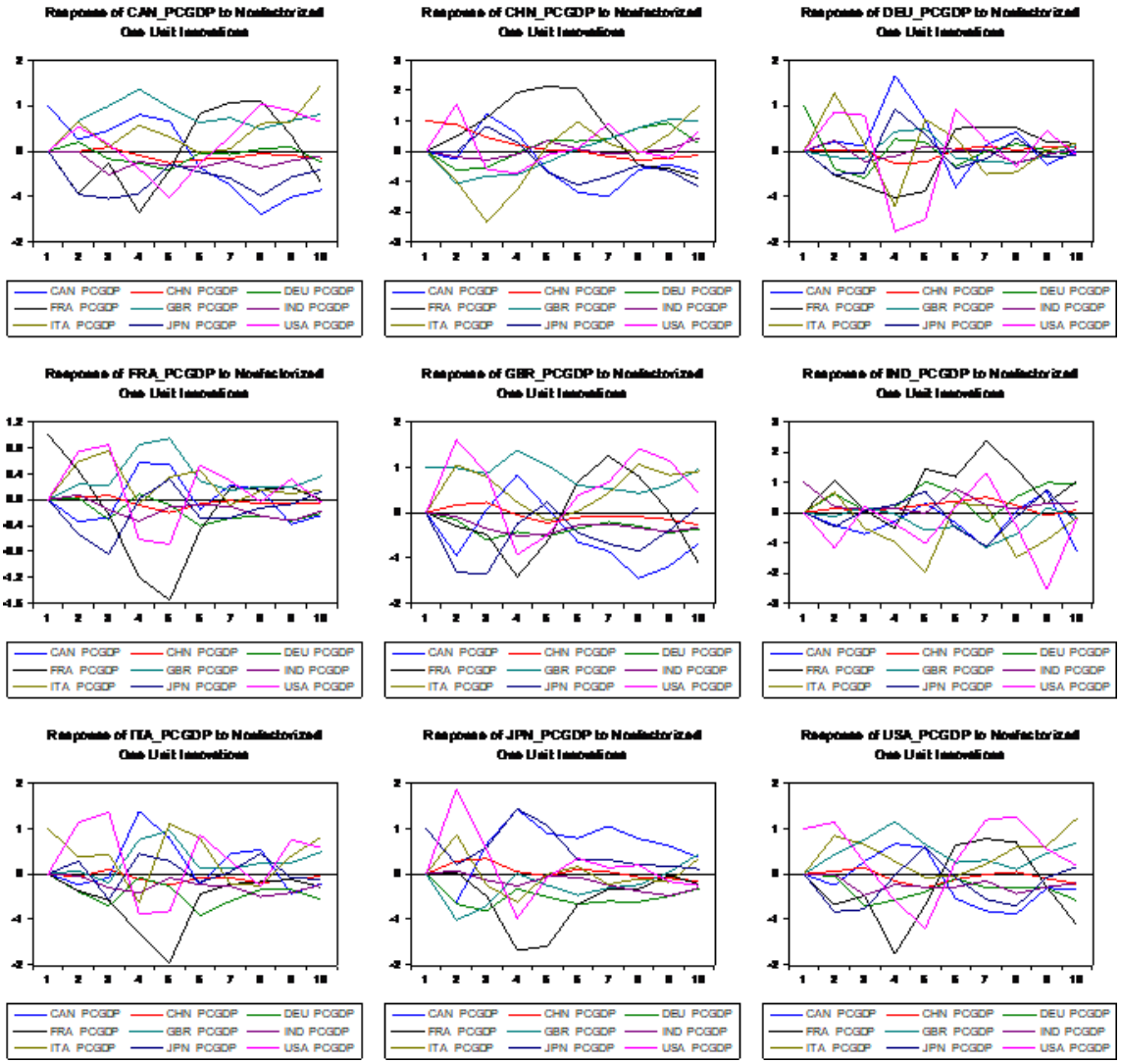


Figure A.36: Residual Impulse Responses for G9 VAR(3) – Combined Impulse Response - 1970-2010 Sample

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