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How US Fiscal and Monetary Policy affect the GDP of Countries with Fixed and Flexible Exchange Rates: Estimates using Korean Data from 1963 to 2022

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Abstract The simplest large country IS/LM/BP model (Mundell-Fleming Model) predicts that an increase in Government spending in the US would cause an increase in Gross Domestic Product (GDP) for countries with flexible exchange rate regimes and decreases in GDP for countries with fixed exchange rate regimes. In contrast, increases in the US money supply would cause an increase in GDP for countries with fixed exchange rate regimes and decreases in GDP for countries with flexible exchange rate regimes. This paper uses a solution to the omitted variables problem of regression analysis to estimate the effects of US fiscal and monetary policy on the Republic of Korea using quarterly data. The data splits into two sections: (1) from 1962 through 1997, Korea had a fixed exchange rate regime and (2) from 1998 through 2022, Korea had a flexible exchange rate regime. The empirical results fit the Large Country IS/LM/BP predictions.

Keywords: United States, Mundell-Fleming model, policy coordination, South Korea, spill over effects, fixed versus flexible exchange rate systems

JEL Classifications: F41, F42, N10

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I. Introduction

Daniels and VanHoose (2004) contains a clear explanation of the large country IS/LM/BP model that assumes perfect capital mobility — thus increasing country 1's interest rate will cause capital to flow from country 2 into country 1 putting upward pressure (towards appreciation) on country 1's exchange rate (other currency/country 1's currency) and downward pressure (towards depreciation) on country 2's exchange rate (other currency/country 2's currency). An interesting policy prediction that emerges out of this model is that if country 1 has a flexible exchange rate, then country 1 increasing its money supply will lead to an increase in GDP for countries with fixed exchange rate regimes and decreases in GDP for countries with flexible exchange rate regimes. The opposite is predicted if country 1 increases government spending — increases

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in country 1's government spending will decrease GDP in countries with fixed exchange rate regimes and increase GDP in countries with flexible exchange rate regimes. Thus, if the US (with a flexible exchange rate) goes into recession, then countries with fixed exchange rate regimes want the US to use monetary policy, but countries with flexible exchange rate regimes want the US to use fiscal policy to combat the recession.

In the last 20 years, the theoretical literature on international economic coordination has become much more complex than the simple large country IS/LM/BP model presented by Daniels and VanHoose (2004). Benigno and Benigno (2006) develop a model with nominal rigidities, monopolistic competition, and different types of shocks. Corsetti and Pesenti (2001) develop a model with monopolistic production specific to one country, adjusting terms of trade, different sizes of countries, and inflation shocks. Obstfeld and Rogoff (2002) find that adding nominal rigidities that can interact with other distortions (like monopolies and imperfect capital markets) makes the international coordination theory ambiguous. Carlberg (2005) explores (1) the effects of imperfect capital markets, (2) effects of "going cold turkey" or taking a gradualist approach to international cooperation, (3) adaptive or rational expectations, (4) two, three, or more world regions, (5) different countries having different policy multipliers, (6) different sizes of the countries, (7) different degrees of capital mobility between countries, (8) labor unions that compete or cooperate across international borders, and (9) inflation. Berger and Wagner (2006) develop a two-country model with sticky prices, vertical trade, and different monetary targeting goals (consumer price index, producer price index, nominal income, or money supply). Sugandi (2020) develops a dynamic stochastic general equilibrium model with two factors of production and four economic agents (households, firms, government, and central banks). He finds that the relative size of the countries attempting coordination is a dominant variable. Clarida, Gali, and Gertler (2002), Engel (2011), and Fujiwara and Wang (2017) develop monetary coordination models around Nash equilibriums which incorporate subsets of the forces considered by the other authors surveyed here. Kim (2023) develops a model with different types of export pricing (local pricing versus producer currency pricing) and explores the effects of which country's policy makers can manipulate prices.

Using traditional statistical techniques to develop an empirical test that would include all the variables that the above literature finds important would be impossible — it would require a model that includes everything that can affect GDP, interest rates, and exchange rates, and can account for heterogeneous countries containing any possible market distortion. Furthermore, how these forces are modelled can dramatically affect the empirical estimates produced. Cogan et al. (2010) using the same data found very different government spending multipliers when a Romer-Bernstein Keynesian model is used versus a Taylor Keynesian model. Fortunately, Leightner (2015) and Leightner, et al. (2021) explain Reiterative Truncated Projected Least Squares (RTPLS) — a solution to the omitted variables problem of regression analysis which makes estimations possible without having to develop and justify complete macroeconomic models. Applying RTPLS to quarterly data from 1962 to 1997 (during which time the Republic of Korea had a fixed exchange rate regime) produces estimates where increases in US government spending decreased Korea's GDP while increases in US money supply increased Korea's GDP. The opposite is found for 1998 through 2022 when Korea had a flexible exchange rate regime — increases in US government spending increased Korea's GDP while increases in US money supply decreased Korea's GDP. These results fit the predictions of the simple large country IS/LM/BP model presented in Daniels and VanHoose (2004). However, these effects appear to be diminishing over time.

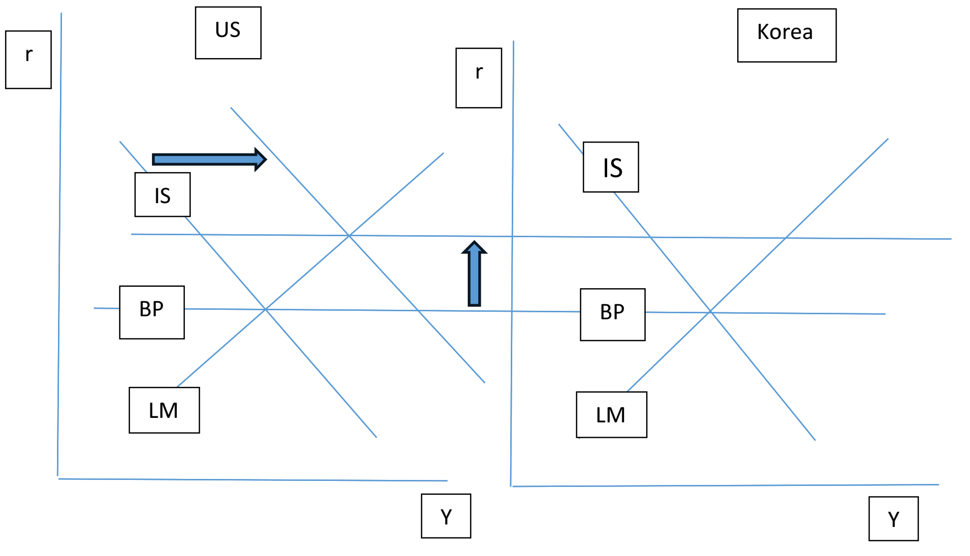
The remainder of this paper is organized as follows. Section 2 provides a simplified explanation of the IS/LM/BP predictions (simplified means feedback effects from Korea (a small open economy) to the USA (a large open economy) are not considered). These predictions will be empirically tested in Section 4 using the statistical technique explained in Appendix I, applied to the data explained in Section 3. Section 5 concludes.

II. The Large Country IS/LM/BP Predictions

The IS curve shows all the interest rate (r) and income (Y = GDP) combinations that produce equilibrium in the real market. The IS curve is downward sloping because an increase in interest rates causes investment to fall, causing aggregate demand to fall, causing a decline in GDP. The LM curve shows all the interest rate and income combinations that produce equilibrium in the domestic money market. LM has a positive slope because increases in income cause the transactions demand for money to increase, causing the domestic demand for money to increase, driving up interest rates. The BP line shows all the interest rate and income combinations that produce equilibrium in the international money market. If international capital can freely move without any impediment between countries, then BP is horizontal at the world interest rate. If international capital is completely blocked from moving in and out of a specific country, then that country's BP line is vertical.

In the simplest large country IS/LM/BP analysis, capital is assumed to be perfectly mobile making the BP line horizontal at the world's interest rate for both countries. In Figure 1, the US increases government spending (G) which shifts the IS curve to the right, driving up US interest rates. In response capital moves from the rest of the world (including Korea) into the US putting upward pressure on the US exchange rate (€/$) and downward pressure on Korea's exchange rate ($/won). If Korea has a fixed exchange rate regime, then the Korean government must buy up the resulting surplus of Korean won on the international market, pulling that surplus currency out of circulation, which reduces Korea's money supply. A reduction of Korea's money supply shifts Korea's LM curve to the left causing a fall in Korea's GDP (Y). In Figure 1, the LM curve would shift to the left until a new three-way equilibrium is found.[1)] Thus the US increasing government spending hurts countries with fixed exchange rate regimes.

Figure 1. Large country IS/LM/BP if the US increases government spending



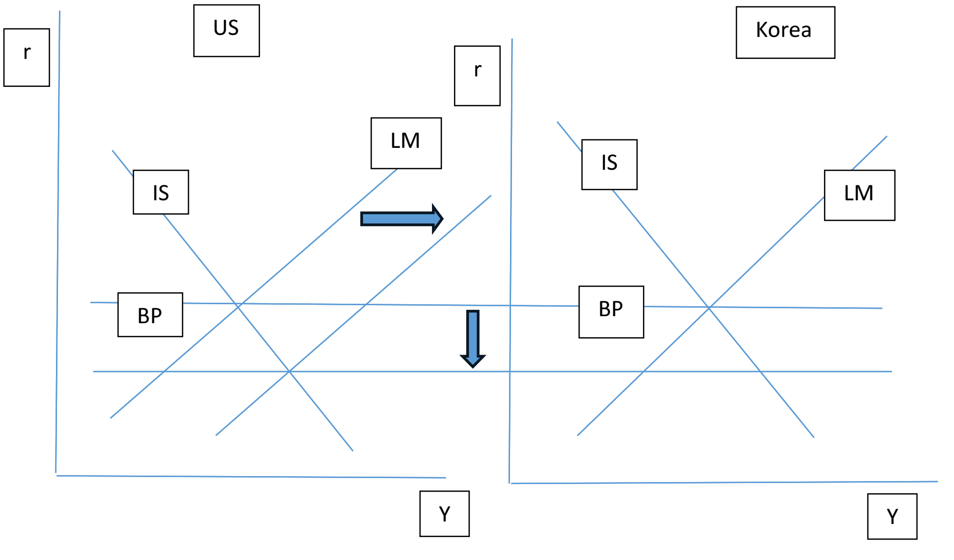
If Korea has a flexible exchange rate regime, then the story is the same as given above up to what happens to Korea's exchange rate ($/won). If Korea has a flexible exchange rate regime, then Korea's exchange rate ($/won) would fall (won would depreciate) causing BP to shift horizontally to the right which will pull IS with it to the right. BP shifts to the right because a lower exchange rate ($/won) is consistent with a higher level of imports and imports increase as GDP increases. However, in the perfect capital mobility case, the horizontal shift in the BP line is invisible because BP is a horizontal line shifting horizontally along itself. However, the fall in the exchange rate ($/won) would cause exports to rise and imports to fall, which causes aggregate demand and IS to shift to the right. Thus, in Figure 1, the international adjustment for Korea would appear as the IS curve shifting to the right to create a new three-way equilibrium which would increase Korea's GDP (Y). Therefore, the US increasing government spending helps countries with flexible exchange rate regimes.

If instead of increasing government spending (as shown in Figure 1), the US increased its

1) The Large Country IS/LM/BP model is more complex than presented here in that what happens in Korea would have feedback effects on the US. In a more complex IS/LM/BP model the world interest rate will end up somewhere between the initial and final interest rates show in Figure 1 and the shifts are more complex than what is presented here. However, the model as presented here explains the major reasons for the IS/LM/BP predictions which is what is needed for this paper. Furthermore, since Korea can be regarded as a small open economy, it is reasonable to simplify the large country IS/LM/BP model by not showing feedback effects from Korea to the USA.

money supply (as shown in Figure 2) then the opposite of the above conclusions are found. The US increasing its money supply would shift the US LM curve to the right as shown in Figure 2. The resulting decrease in US interest rates would cause capital to move from the US into the rest of the world, including Korea. The fall in US interest rates would put downward pressure (towards depreciation) on the US exchange rate (€/$) and upward pressure (towards appreciation) on the Korean exchange rate ($/won). If Korea has a fixed exchange rate regime, a shortage of Korean won on the international money model results. To maintain its fixed exchange rate, Korea must eliminate this shortage by printing more won and exchanging it for US dollars (or some other major international currency). This process increases Korea's money supply shifting Korea's LM curve to the right in Figure 2 (until there is a new three-way equilibrium) which results in an increase in Korea's GDP (Y). Thus, increases in the US money supply result in an increase in Korea's GDP, but increases in US government spending reduce Korea's GDP.

Figure 2. Large country IS/LM/BP if the US increases its money supply



If Korea has a flexible exchange rate regime and the US increases its money supply, then the opposite happens. Again, the story for the flexible exchange rate regime is the same as the story for the fixed exchange rate regime up to what happens to Korea's exchange rate ($/won). Under a flexible exchange rate regime, US dollars per Korean won rises (appreciates) shifting Korea's BP horizontally to the left which pulls Korea's IS curve to the left also. Korea's BP line shifts horizontally to the left because a higher exchange rate ($/won) is consistent with less imports which is consistent with a lower GDP (Y). However, again it is impossible to see the horizontal shift of a horizontal line along itself. The rise in Korea's exchange rate will reduce Korea's exports and increase Korea's imports, causing Korea's aggregate demand and IS curves to shift left. Korea's IS curve will shift left until there is a new three-way equilibrium in Figure 2. This leftward shift in Korea's IS curve would decrease Korea's GDP (Y). Thus, increases in the US money supply hurt Korea if it has a flexible exchange rate regime, but help Korea if Korea has a fixed exchange rate regime.

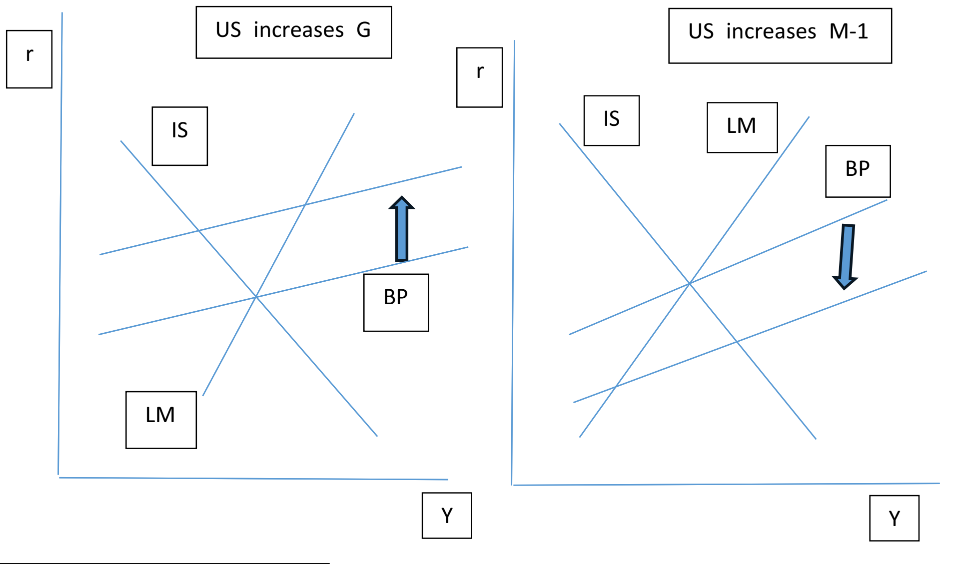
This paper empirically tests to see if the large country IS/LM/BP predictions hold for Korea when Korea had a fixed exchange rate regime from 1962 through 1997 and when Korea had a flexible exchange rate regime from 1998 through 2022 using the statistical technique explained in Appendix I. However, before empirically testing the large country IS/LM/BP model predictions, it is useful to compare these predictions to the predictions that emerge from a small country IS/LM/BP model. It is important to realize that the perfect capital mobility assumption made by the large country IS/LM/BP model noticeably simplifies what that model would predict. Some of the small country IS/LM/BP cases are not tractable in that the model, by itself, does not produce a clear prediction.

The small country IS/LM/BP model divides into four cases. In the perfectly immobile case, the BP line is vertical because the international money market for that country does not respond to changes in interest rates either due to prohibitive capital controls or due to international expectations of extremely high risk. In the relatively immobile (mobile) case the upward sloping BP line is steeper (flatter) than the LM line meaning that the domestic money market is more (less) sensitive to changes in the interest rate than the international money market is. In the perfectly mobile case, the BP line is horizontal, and that case is identical to the large country IS/LM/BP case explained above.

An increase in US government consumption would cause (1) US GDP to increase which would result in an increase in US imports, and thus an increase in Korean exports causing Korea's BP and IS curves to shift rightward and (2) US interest rates to rise causing capital to move from Korea to the US, causing Korea's BP line to shift upward. An increase in the US money supply would also cause Korea's BP and IS curves to shift right for the same reason as given in (1) of the previous sentence; however, the effect on the interest rate would be the opposite of (2) resulting in Korea's BP line shifting downward. If capital is perfectly immobile then effect (2) does not occur. In all other cases, both the income effect (1) and the interest rate effect (2) occur; however, which effect dominates depends upon the mobility of capital. If capital is perfectly or relatively immobile, then the income effect (1) dominates; if capital is perfectly or relatively mobile, then the interest rate effect (2) dominates. To promote clarity, the diagrams below only show the dominant effect.

Figure 3 shows the case of relatively mobile capital. In the relatively mobile case, BP is flatter than LM and only the BP shift is shown because the interest rate effect dominates over the income effect. An increase in US government consumption drives up US interest rates causing capital to move from Korea to the US, causing Korea's BP line to shift upward. In contrast an increase in the US money supply causes US interest rates to fall, causing capital to move from the US to Korea, causing Korea's BP line to shift downward. These shifts mirror the large country shifts explained in greater detail above. Likewise in this case, the small country IS/LM/BP predictions mirror the large country predictions — if Korea has a fixed exchange rate regime (and thus LM shifts to establish a new three-way equilibrium) an increase in US government consumption hurts Korea (Korea's Y falls) whereas an increase in US money supply helps Korea. However, the opposite is true if Korea has a flexible exchange rate. As explained above, under a flexible exchange rate, the international adjustment involves BP shifting to produce a new three-way equilibrium and BP pulling IS horizontally with it in the same direction. In diagram 3, both the BP and the IS shift can only be shown if BP moves in the opposite direction of the arrows.[2] For the increased US government consumption case, this would involve the BP line shifting to the right, pulling IS with it, creating an increase in Korea's GDP (Y). For the increased in US money supply, BP would need to shift left, pulling IS with it resulting in a fall in Korea's GDP. Thus an increase in US government spending helps Korea if Korea has a flexible exchange rate regime and hurts Korea if Korea has a fixed exchange rate regime. In contrast, an increase in the US money supply hurts Korea if Korea has a flexible exchange rate regime and helps Korea if Korea has a fixed exchange rate regime - the same predictions made for the perfectly mobile case as shown in Figures 1 and 2.

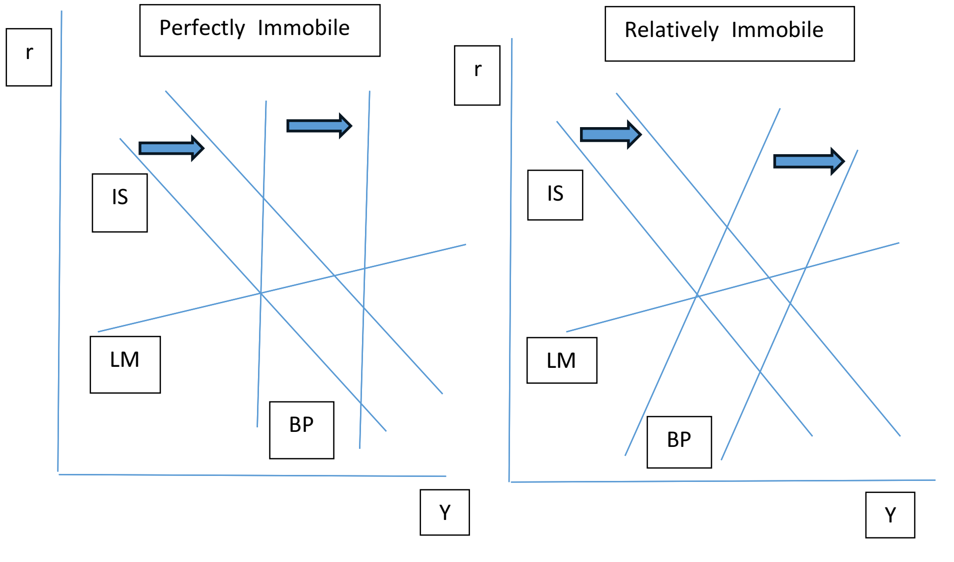
Figure 3. Small country IS/LM/BP for Korea if capital is relatively mobile



2) It is very important to realize that BP determines the direction of the international adjustment, not IS. BP determines this direction because the international adjustment for flexible exchange rate regimes involves a change in the exchange rate (which shifts BP). The change in the exchange rate produces changes in exports and imports which shift IS. Thus the international adjustment for flexible exchange rates is "BP adjusts and BP pulls IS horizontally with it in the same direction."

Figure 4 shows the perfectly immobile (on the left) and relatively immobile (on the right) cases for an increase in either US government consumption or US money supply, both of which would cause an increase in US income, thus of US imports, and thus of Korean exports. If capital is perfectly or relatively immobile, then the income effect dominates over the interest rate effect, and only the dominant effect is shown in Figures 1 through 4. An increase in Korean exports would shift both the BP and IS curves to the right. Figure 4 shows the BP line shifting more than the IS line; however, IS/LM/BP theory does not say which curve (BP or IS) will shift more. Which line will shift more depends on many factors including the strength of the Keynesian multiplier effect on aggregate demand, the marginal propensity to import, the ratio of Korean net exports to Korean GDP, the slope between the exchange rate ($/won) versus Korean exports and imports, the strength of capital controls, the degree that changes in interest rates affect domestic investment, international investment, and consumption. If Korea has a fixed exchange rate regime, then LM (as explained above) will adjust to produce a new three-way equilibrium resulting in an increase in Korean GDP.[3] If Korea has a flexible exchange rate regime, the BP line adjusts and BP pulls IS horizontally in the same direction, which will "probably" cause a net increase in Korea's GDP. Thus, if capital is perfectly or relatively immobile, then it is possible that both US fiscal and monetary policy could help a country with a flexible exchange rate — contrary to the large country IS/LM/BP prediction.

Figure 4. Small country IS/LM/BP for Korea if capital is perfectly or relatively immobile and the US increases either government consumption or the money supply



3) If IS shifts more than BP in the initial shift, then LM will need to shift left, but there will still be a "net" increase in GDP for Korea.

III. Data Used and Empirical Results

Quarterly data on USA and Korean government consumption and on Korean GDP were downloaded from the OECD database. The government consumption and GDP data were in millions of Korean won for the Korean data and in millions of US dollars for the US data. Monthly data on US and Korean money supply (M1) indices, where June 2015 was equal to 100, was downloaded from the OECD database. This monthly monetary index was changed into quarterly data by averaging the three monthly values of a given quarter. The quarterly money supply data were multiplied by 10,000 to scale them to fit the government consumption and GDP data.[4)]

It is much easier to calculate RTPLS estimates if all the values for the dependent variable (*Y*) and included independent variable (*X*) are positive. If some of the *Y* values (*X* values) are negative, then a constant should be added to all the *Y* values (*X* values) so that all of them become positive. Adding a constant to all *Y*s and/or to all *X*s does not change the resulting slope. However, this did not have to be done in this paper because all the values for *Y* and *X*s were positive.

As explained in Appendix I, RTPLS involves peeling the data down layer by layer. The top layer corresponds to when omitted variables are at their most favorable levels (where favorable means increasing the dependent variable the most). The second layer corresponds to when omitted variables are at their second most favorable levels, etc. Before peeling the data, it must be decided whether the layers represent a positive relationship between the dependent variable (*Y*) and the included independent variable (*X*) or a negative relationship.[5)] If the relationship between *Y* and *X* is negative, then all values of *Y* (but not *X*) should be multiplied by negative one and a constant added to make all of the *Y* values positive again. This process changes the true negative slope into a positive slope without changing the absolute value of that slope. Once the RTPLS process is completed, the RTPLS estimates will need to be remultiplied by negative one to change them back into negative values. A researcher can either use theory or run a preliminary OLS regression to decide if a positive or negative relationship should be

4) Before multiplying the money supply indices by 10,000 the data for the third quarter of 1962 was KGDP = 88,650 million won, KG = 14,240 million won, KM1 = 0.006567, USM1 = 4.8475, USG = 24,735 million dollars, and USGDP = 152,257 million dollars. Multiplying the money supply indices in the third quarter of 1962 by 10,000 change them into KM1 = 65.67 and USM1 = 48,475 which fits the rest of the data better. Before multiplying the money supply indices by 10,000 the data for the fourth quarter of 2022 was KGDP = 539,324,400 million won, KG = 104,217,900 million won, KM1 = 198.4494, USM1 = 660.6023, USG = 921,009 million dollars, and USGDP = 6,534,498 million dollars. Multiplying the money supply indices for the fourth quarter of 2022 by 10,000 change them into KM1 = 1,984,494 and USM1 = 6,606,023.

5) Most simulations testing RTPLS tested situations where the true slope was always either positive or negative. Leightner (2015) ran a few simulations that show that RTPLS can handle situations where omitted variables sometimes make the true slope positive and at other times negative. However, even in those cases (where the true slope is sometimes positive and sometimes negative), a researcher must decide which slope sign dominates. The researcher must then use the dominant slope direction when peeling the data. When possible, it is best to split the data into sections where the true slope is always positive or always negative, which is what is done in this paper.

used. In this paper, a preliminary regression produced the signs that theory would predict (Appendix II explains what happens when a log linear specification is used and argues that the linear specification presented here is better supported by theory).

The preliminary regression for when Korea had a fixed exchange rate regime (quarter 3 of 1962 through the 4th quarter of 1997) produced the following results with an *R Squared* of 0.998 (standard errors are given in parentheses under the estimates: *, **, and *** indicates 90, 95, and 99 percent confident the true coefficient is not zero respectively, KG = Korea's government consumption, KM1 = Korea's Money Supply, USM1 = US Money Supply, and USG = US government consumption):

Korea's GDP = 571664.8 + 10.04902 KG - 6.99877 KM1 + 9.662209 USM1 - 25.665 USG
(1491452) (0.27667***) (19.8272) (10.0817) (12.0208**)

The preliminary regression for when Korea had a flexible exchange rate regime (first quarter of 1998 through fourth quarter of 2022) produced the following results (*R Squared* of 0.993).

Korea's GDP = 35010294 + 4.384804KG + 16.6715 KM1 - 13.0396 USM1 + 136.0685 USG
(10833626***) (0.33956***) (11.94) (1.403***) (35.17877***)

Notice that the positive and negative signs on *d*(Korea's GDP)/*d*(US's G) and on *d*(Korea's GDP)/*d*(US's M1) under Korea's fixed then flexible exchange rate regimes fit the predictions of the simple large country IS/LM/BP model presented in Daniels and VanHoose (2004).

In order to see how omitted variables have affected *d*(Korea's GDP)/*d*(US's G) and *d*(Korea's GDP)/*d*(US's M1) under Korea's fixed then flexible exchange rate regimes, the influence of the other included independent variables was purged from the data on Korea's GDP (the dependent variable, Y) before RTPLS was used (Leightner, 2015). Specifically, and based upon the above OLS preliminary regressions, the dependent variable used in the RTPLS process for *d*(Korea's GDP)/*d*(US's G) from 1962 through 1997 is given in equation (1), and for 1998 through 2022 is given in equation (2). The dependent variable used in the RTPLS process for *d*(Korea's GDP)/*d*(US's M1) from 1962 through 1997 is given in equation (3), and for 1998 through 2022 is given in equation (4).

Y purged = Korea's GDP - [571664.8 + 10.04902 KG - 6.99877 KM1 + 9.662209 USM1] (1)

Y purged = Korea's GDP - [35010294 + 4.384804KG + 16.6715 KM1 - 13.0396 USM1] (2)

$$Y \text{ purged} = \text{Korea's GDP} - [571664.8 + 10.04902\ KG - 6.99877\ KM1 - 25.665\ USG] \tag{3}$$

$$Y \text{ purged} = \text{Korea's GDP} - [35010294 + 4.384804KG + 16.6715\ KM1 + 136.0685\ USG] \tag{4}$$

The RTPLS process was applied four times - once for each of the equations (1) through (4) using the data that corresponds to each individual equation. The RTPLS estimates produced are given in Table 1 and depicted in Figures 5 and 6. All of the RTPLS estimates were significantly different from zero as calculated by equation (15) in Appendix I.

IV. Discussion

The variations in the RTPLS estimates shown in Table 1 and Figures 5 and 6 are due to omitted variables. These omitted variables could include changes in the degree of market power, adjusting terms of trade, changes in the economic size of countries and changes in the degree that countries are connected to the international market, changing nominal rigidities interacting with other changing distortions, and/or inflation shocks (Corsetti and Pesenti, 2001, Benigno and Benigno, 2006, and Obstfeld and Rogoff, 2002). These omitted variables could also include changes in the imperfections of capital markets, changes in how expectations are formed, changes in the policy multipliers of different countries, changes in the degree of capital mobility between countries, and/or changes in the interactions of labor unions across international borders (Carlberg, 2005). Furthermore, some of the RTPLS estimate variation could be due to changing targets for monetary policy in different countries (Berger and Wagner, 2006) or changes in which policy makers can manipulate prices and by how much (Kim, 2023).

Most of the forces mentioned in the previous paragraph are likely to change slowly, thus, their influence are likely to be reflected in the general trends shown in Figures 5 and 6. Figure 5 shows that *d*(Korea's GDP)/*d*(US Money Supply) tended to head towards zero under both the fixed exchange rate and flexible exchange rate regimes (although all these estimates are significantly different from zero at a 95 percent confidence level as calculated by equation (15) in Appendix I). Likewise *d*(Korea's GDP)/*d*(US Government Consumption) also tended to move closer to zero when Korea was under a flexible exchange rate. However, a major reason for these downward trends is probably the devaluation/depreciation of the Korean won relative to the US dollar over time.

Table 1. *The Change in Korea's GDP due to U.S. Policies*

	dUSG	dUSM1		dUSG	dUSM1		dUSG	dUSM1
1962.3	-11.723	111.324	1982.4	-35.049	30.464	2002.4	292.99	-27.591
1962.4	-10.139	111.668	1983.1	-22.568	41.091	2003.1	288.54	-29.382
1963.1	-9.914	110.762	1983.2	-22.411	40.336	2003.2	283.51	-31.862
1963.2	-10.097	109.757	1983.3	-20.992	40.999	2003.3	284.12	-29.914
1963.3	-10.480	108.821	1983.4	-21.624	39.843	2003.4	289.08	-22.338
1963.4	-9.614	108.454	1984.1	-14.595	45.549	2004.1	288.98	-19.374
1964.1	-9.346	108.026	1984.2	-16.709	43.364	2004.2	284.88	-21.376
1964.2	-8.643	107.801	1984.3	-14.951	44.820	2004.3	280.20	-23.759
1964.3	-8.513	106.428	1984.4	-18.005	41.897	2004.4	275.31	-26.694
1964.4	-8.354	105.256	1985.1	-23.144	36.545	2005.1	267.80	-32.148
1965.1	-9.026	104.308	1985.2	-16.683	41.743	2005.2	268.51	-30.148
1965.2	-9.787	103.523	1985.3	-13.823	43.409	2005.3	262.36	-34.178
1965.3	-9.928	102.742	1985.4	-15.587	41.082	2005.4	267.05	-27.122
1965.4	-8.308	102.345	1986.1	-15.067	40.928	2006.1	253.88	-39.199
1966.1	-9.876	100.041	1986.2	-14.415	40.494	2006.2	250.02	-42.343
1966.2	-9.341	99.701	1986.3	-12.758	40.806	2006.3	251.92	-39.064
1966.3	-9.036	100.566	1986.4	-12.504	39.783	2006.4	249.99	-39.262
1966.4	-8.944	100.510	1987.1	-9.038	41.657	2007.1	249.06	-38.407
1967.1	-8.783	100.254	1987.2	-20.906	31.996	2007.2	253.25	-30.994
1967.2	-9.229	98.918	1987.3	-5.747	43.952	2007.3	253.57	-28.529
1967.3	-9.244	97.208	1987.4	-5.910	43.837	2007.4	253.01	-26.376
1967.4	-8.343	96.687	1988.1	-3.553	45.607	2008.1	251.27	-32.568
1968.1	-8.676	95.791	1988.2	-10.061	39.973	2008.2	245.48	-32.077
1968.2	-8.790	94.449	1988.3	-12.309	37.922	2008.3	219.56	-63.022
1968.3	-9.408	92.666	1988.4	-9.514	40.455	2008.4	216.56	-63.981
1968.4	-9.870	90.857	1989.1	-18.987	32.807	2009.1	215.47	-60.508
1969.1	-9.779	89.500	1989.2	-24.068	28.876	2009.2	215.34	-57.559
1969.2	-8.913	89.738	1989.3	-28.082	25.347	2009.3	227.50	-42.315
1969.3	-8.791	89.806	1989.4	-24.527	28.196	2009.4	224.93	-43.422
1969.4	-8.887	89.298	1990.1	-29.098	24.002	2010.1	233.80	-32.552
1970.1	-8.003	89.261	1990.2	-32.504	20.798	2010.2	241.26	-23.331
1970.2	-8.841	88.182	1990.3	-24.827	27.385	2010.3	244.52	-20.004
1970.3	-8.543	87.613	1990.4	-33.016	19.928	2010.4	241.80	-22.225
1970.4	-10.190	85.285	1991.1	-24.551	27.294	2011.1	245.04	-18.678
1971.1	-9.048	85.189	1991.2	-24.537	26.966	2011.2	244.01	-18.848
1971.2	-10.046	83.140	1991.3	-28.599	23.068	2011.3	247.04	-16.876
1971.3	-9.379	82.509	1991.4	-31.753	20.003	2011.4	251.96	-12.702
1971.4	-9.552	81.875	1992.1	-30.057	20.961	2012.1	246.24	-16.750
1972.1	-9.716	80.822	1992.2	-32.671	18.463	2012.2	251.00	-13.201
1972.2	-10.084	79.579	1992.3	-44.239	8.614	2012.3	244.32	-17.991
1972.3	-11.274	77.287	1992.4	-44.556	8.275	2012.4	248.77	-14.280

Table 1. *Continued*

	dUSG	dUSM1		dUSG	dUSM1		dUSG	dUSM1
1972.4	-10.257	76.560	1993.1	-37.899	13.551	2013.1	245.07	-16.940
1973.1	-7.288	77.526	1993.2	-33.776	16.547	2013.2	245.30	-16.451
1973.2	-7.699	76.652	1993.3	-31.237	18.175	2013.3	248.51	-14.082
1973.3	-7.004	76.503	1993.4	-27.815	20.430	2013.4	248.01	-14.205
1973.4	-6.910	76.103	1994.1	-20.184	25.824	2014.1	248.93	-13.164
1974.1	-4.162	77.397	1994.2	-24.336	22.741	2014.2	246.74	-14.612
1974.2	-5.432	76.158	1994.3	-19.238	26.422	2014.3	241.18	-17.418
1974.3	-6.591	75.248	1994.4	-16.928	28.135	2014.4	242.44	-16.646
1974.4	-16.354	67.511	1995.1	-12.441	31.553	2015.1	256.86	-7.056
1975.1	-9.990	72.358	1995.2	-10.622	33.069	2015.2	247.98	-12.182
1975.2	-12.786	69.500	1995.3	-11.367	32.604	2015.3	260.53	-3.613
1975.3	-9.296	71.370	1995.4	-11.184	44.415	2015.4	251.44	-9.316
1975.4	-19.275	63.160	1996.1	-27.060	20.925	2016.1	255.01	-7.075
1976.1	-13.221	67.285	1996.2	-23.939	23.403	2016.2	257.00	-5.475
1976.2	-10.086	68.931	1996.3	-25.292	22.513	2016.3	248.23	-10.231
1976.3	-10.979	67.735	1996.4	-27.068	21.278	2016.4	250.71	-8.392
1976.4	-17.169	62.042	1997.1	-25.756	22.438	2017.1	254.24	-6.133
1977.1	-15.210	62.525	1997.2	-18.818	28.591	2017.2	249.84	-8.703
1977.2	-16.087	60.988	1997.3	-12.481	34.012	2017.3	259.54	-2.769
1977.3	-12.596	63.172	1997.4	-13.794	33.031	2017.4	245.19	-10.170
1977.4	-8.625	65.641				2018.1	236.85	-14.129
1978.1	-10.416	63.257	1998.1	329.27	-47.597	2018.2	232.82	-15.654
1978.2	-12.234	60.767	1998.2	305.16	-65.409	2018.3	229.31	-16.809
1978.3	-8.836	62.862	1998.3	302.82	-66.267	2018.4	213.84	-25.415
1978.4	-4.159	66.104	1998.4	299.53	-65.626	2019.1	203.77	-30.984
1979.1	-10.167	60.832	1999.1	310.77	-53.637	2019.2	195.81	-34.699
1979.2	-8.920	60.703	1999.2	310.60	-51.208	2019.3	187.31	-38.967
1979.3	-6.403	61.932	1999.3	317.51	-41.042	2019.4	176.73	-44.194
1979.4	-7.225	61.325	1999.4	316.88	-37.159	2020.1	157.03	-54.422
1980.1	-26.225	44.872	2000.1	320.75	-33.061	2020.2	188.55	-20.394
1980.2	-24.350	46.716	2000.2	315.72	-33.550	2020.3	227.09	-13.173
1980.3	-27.496	42.755	2000.3	322.14	-26.178	2020.4	231.49	-12.495
1980.4	-25.540	43.596	2000.4	312.12	-33.705	2021.1	226.29	-12.681
1981.1	-36.217	33.677	2001.1	301.00	-40.383	2021.2	220.89	-13.273
1981.2	-30.271	38.074	2001.2	304.21	-34.024	2021.3	220.02	-13.232
1981.3	-27.939	40.039	2001.3	296.53	-38.643	2021.4	214.16	-13.816
1981.4	-23.311	43.872	2001.4	285.04	-48.137	2022.1	209.95	-14.176
1982.1	-25.005	41.569	2002.1	298.61	-30.323	2022.2	208.10	-14.165
1982.2	-22.329	43.717	2002.2	299.37	-26.380	2022.3	200.24	-15.095
1982.3	-25.890	40.083	2002.3	300.11	-23.689	2022.4	178.58	-18.018

Figure 5. The change in Korea's GDP due to a change in the US's money supply

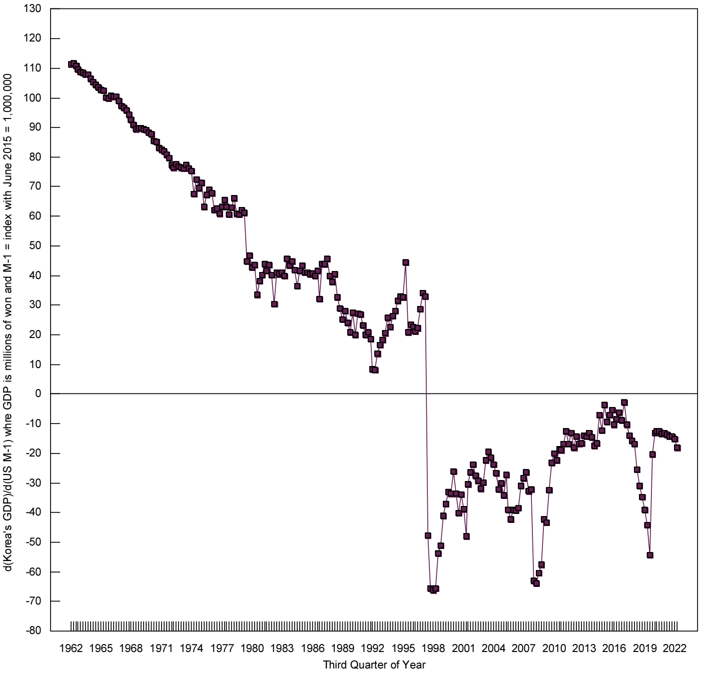
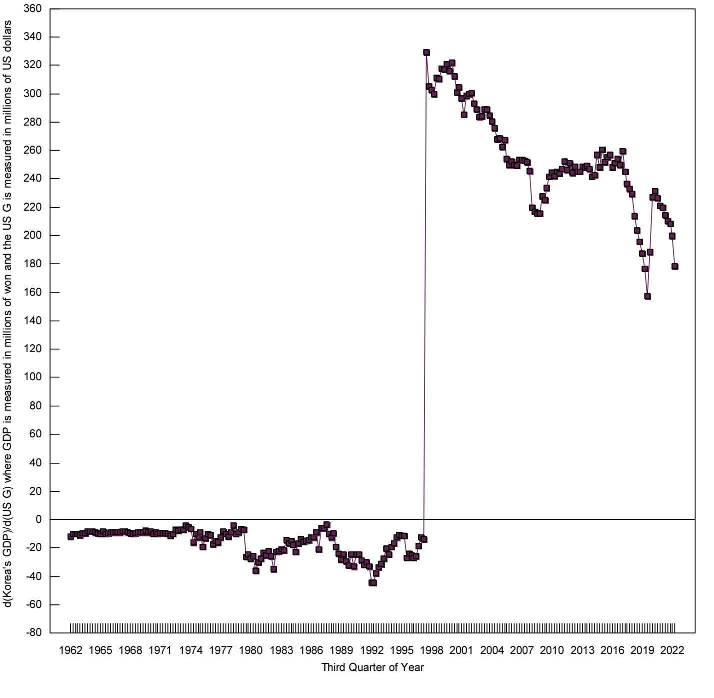


Figure 6. The change in Korea's GDP due to a change in the US's government consumption



Figures 5 and 6 also reflect the influence of some specific events. The great recession of 2008 and the pandemic that started in 2019 caused both the US money supply and government consumption multipliers to noticeably fall. Furthermore, the assassination of Park Chung Hee in 1979 is also reflected in a change in both figures. Moreover, Korea's liberation of the capital account in the 1990s is clearly reflected in Figure 5.

The empirical results produced in this paper fit the predictions of the large country IS/LM/BP model as presented in Daniels and VanHoose (2004) where 1992 through 1997 corresponds to Korea having a fixed exchange rate regime and 1998 through 2022 Korea having a flexible exchange rate regime. One of the short comings of the simple IS/LM/BP model presented by Daniels and VanHoose (2004) is its treatment of countries either having a perfectly fixed exchange rate regime or a perfectly flexible exchange rate regime. Many countries use managed floats or other exchange rate systems which lie somewhere between fixed and flexible exchange rate regimes. Indeed, neither Korea's "fixed exchange rate regime" from 1962 through 1997 nor Korea's "flexible exchange rate regime" from 1998 through 2022 were "perfect." Between 1962 and 1980, Korea devalued the Korean won four times going from one dollar for 125 won to one dollar for 580 won (devaluations occurred in May 1964, August 1972, December 1974, and January 1980). Then between January 1980 and December 1997, the US dollar per Korean won exchange rate does not follow the stepwise pattern that one would expect of a fixed exchange rate that is periodically devalued because, during this time, Korea was trying to move its exchange rate system closer and closer to a flexible one. Officially, Korea has had a flexible exchange rate regime since January 1998. However, under a "perfectly" flexible exchange rate regime, a country's foreign reserves do not change. In contrast, Korea's foreign reserves increased from 52 billion dollars in 1998 to 263 billion dollars in 2007, fell to 202 billion dollars in 2008, rose to 463 billion dollars in 2021, and fell again to 423 billion dollars in 2022. In spite of Korea not having a "perfectly" fixed and then a "perfectly" flexible exchange rate regime, the results presented in this paper fit the predictions of a simple IS/LM/BP large country model.

V. Conclusion

It is hard to coordinate fiscal and monetary policies internationally when a country like the US goes into recession. The US can choose to use fiscal and/or monetary policy to combat the recession, but using fiscal policy would help countries with flexible exchange rate regimes and hurt countries with fixed exchange rate regimes while using monetary policy would help countries with fixed exchange rate regimes and hurt countries with flexible exchange rate regimes.[6] So, the

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6) However, under a small country IS/LM/BP model, it might be possible for both US fiscal and monetary policy to help a small country (see section 2).

US is faced with the difficult choice of which countries to help and which to hurt when trying to combat the US recession. How one country's fiscal and monetary policies affect countries with fixed and flexible exchange rate regimes in opposite ways is predicted by a simple large country IS/LM/BP model and empirically tested in this paper for Korea between 1962 and 2022.

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Appendix I. Statistical Technique Used

In order to estimate how US fiscal and monetary policy affected Korea's GDP when Korea had a fixed exchange rate regime and then when Korea had a flexible exchange rate regime, a researcher would either need to (1) develop, justify, and estimate every equation in an international model that included every force that could affect Korea's and the US's GDP, interest rates, exchange rates, etc. or (2) forego the gathering of data and the modelling of the thousands of forces needed for option (1) and instead use a solution to the omitted variables problem of regression analysis. RTPLS is a solution to the omitted variables problem of regression analysis. RTPLS produces a separate slope estimate for every observation where differences in these slope estimates are due to omitted variables. By plotting RTPLS estimates over time, a researcher can see how omitted variables have affected the estimated relationship over time, and the researcher does not need to build and justify a model in the process. Thus, RTPLS estimates are not model dependent. How RTPLS solves the omitted variables problem is explained next.

If a researcher estimates equation (5) while ignoring equation (6), the resulting estimate of β_1 is a constant when in truth β_1 varies with q_t. This constitutes an "omitted variable" problem where "q_t" represents the combined influence of all omitted variables plus any random variation in β_1 itself, Y is the dependent variable, X is the included independent variable, and u is random error.

$$Y_t = \alpha_0 + \beta_1 X_t + u_t \tag{5}$$

$$\beta_1 = \alpha_1 + \alpha_2 q_t \tag{6}$$

One convenient way to model the omitted variable problem is to combine equations (5) and (6) to produce equation (7).

$$Y_t = \alpha_0 + \alpha_1 X_t + \alpha_2 X_t q_t + u_t. \tag{7}$$

Equation (11) can be derived from equation (7) as shown below (Leightner, 2015; Leightner, et al., 2021).

$$(dY_t /dX_t)^{True} = \alpha_1 + \alpha_2 q_t \quad \text{Derivative of (7)} \tag{8}$$

$$Y_t /X_t = \alpha_0/X_t + \alpha_1 + \alpha_2 q_t + u_t /X_t \quad \text{(7) divided by } X \tag{9}$$

$$\alpha_1 + \alpha_2 q_t = Y_t /X_t - \alpha_0/X_t - u_t /X_t \quad \text{(9) rearranged} \tag{10}$$

$$(dY_t /dX_t)^{True} = Y_t /X_t - \alpha_0/X_t - u_t /X_t \quad \text{From (8) and (10)} \tag{11}$$

If an estimate for α_0 could be found, then it could be used to calculate a separate slope estimate for each observation using equation (12). The error due to such a procedure is shown in equation (13). The u_t/X_t term in equation (13) should be extremely small because random error, u_t, is usually tiny relative to the size of X_t, making u_t/X_t even smaller. This implies that the accuracy of calculating a separate slope estimate for each observation using equation (12) depends primarily upon the accuracy of the α_0 estimate.

$$\widehat{(dY_t/dX_t)} = Y_t/X_t - \widehat{\alpha_0}/X_t \qquad (12)$$

$$(dY_t/dX_t)^{True} - \widehat{(dY_t/dX_t)} = (\widehat{\alpha_0} - \alpha_0)/X_t - u_t/X_t \qquad \text{From (7) and (8)} \qquad (13)$$

Leightner et al. (2021) explore three ways to obtain an estimate for α_0: they are (i) using Ordinary Least Squares to estimate equation (5), (ii) using Generalized Least Squares to estimate equation (5), and (iii) using Reiterative Truncated Projected Least Squares (RTPLS) which produces separate slope estimates for layers of the data by peeling the data down layer by layer and then peeling the data up after which equation (14) is used with the resulting layer slopes, $\widehat{(dY_t/dX_t)}_L$ to estimate α_0. Leightner (2015) explains the math that underlies RTPLS.

$$\widehat{(dY_t/dX_t)}_L - Y_t/X_t = -\widehat{\alpha_0}/X_t \qquad \text{(12) rearranged} \qquad (14)$$

Leightner et al. (2021) show that when the omitted variable problem is ignored by estimating equation (5) using OLS, the resulting estimate for β_1 is approximately $\alpha_1 + \alpha_2 E[q_t]$ which leaves an "error" for the t = ith observation of approximately $\alpha_2 X_i(q_i - E[q_i]) + u_i$. The three methods of correcting for the omitted variables problem explored by Leightner et al. (2021) would be better than ignoring the omitted variables problem if $|\widehat{\alpha_0} - \alpha_0)/X_i - u_i/X_i|$ is less than $|\alpha_2\{q_i - E[q_i]\}|$. Aitken (1935) implies that the GLS estimate of α_0 will be the Best Linear Unbiased Estimate (BLUE) if the q_is are i.i.d. $N(\mu_q, \sigma_q^2)$ because GLS is BLUE for heteroscedastic models and Leightner et al. (2021) show that equation (7) is a heteroscedastic model if q_i is unknown.

Leightner et al. (2021) test the three methods using simulations (Leightner 2015 also provides simulation tests but solely for RTPLS). Leightner et al. (2021) run sets of 5,000 simulations each for the 27 combinations of 100 observations, 250 observations, and 500 observations with the omitted variable making a 1,000 percent difference to the slope, a 100 percent difference to the slope, and a 10 percent difference to the slope, and with random error being zero, one percent, and ten percent. Leightner et al. (2021) gives the name "Variable Slope Ordinary Least Squares" (VSOLS) to the process of using OLS to estimate α_0 which is then plugged into equation (12) to generate a separate slope estimate for each observation and the name "Variable

Slope Generalized Least Squares" (VSGLS) to the process using GLS to estimate α_0 which is then plugged into equation (12).

VSGLS and RTPLS noticeably outperformed VSOLS in all simulations. VSGLS and RTPLS outperformed using OLS while ignoring the omitted variables problem except for the case where the omitted variable makes only a ten percent difference to the slope and random error is ten percent. When the importance of the omitted variable was 100 times as big as random error, using OLS while ignoring omitted variables produced approximately 35 times the error of both VSGLS and RTPLS. When the importance of the omitted variable was 10 times as big as random error, then using OLS while ignoring omitted variables produced approximately 3.8 times the error of both VSGLS and RTPLS. When there was no random error, then RTPLS produced less than half the error of VSGLS.[7] This last result implies that, since VSGLS is BLUE, RTPLS must be better than BLUE when there is no random error which is reasonable if RTPLS is better at capturing non-linear aspects of the data.

Confidence intervals for RTPLS estimates can be calculated using the central limit theorem.

$$Confidence\ interval = mean \pm (s/\sqrt{n})t_{n-1,\ \alpha/2} \tag{15}$$

In equation (15), "s" is the standard deviation, "n" is the number of observations, and $t_{n-1, \alpha/2}$ is taken off the standard t table for the desired level of confidence. Leightner et al. (2021) used an estimate along with the 4 estimates before it and a 95% confidence level to create a moving confidence interval (much like a moving average) for a given set of RTPLS estimates. This 95% confidence interval can be interpreted as meaning that there is only a five percent chance that the next RTPLS estimate will lie outside of this range if omitted variables maintain the same amount of variability that they recently have.

7) When the omitted variable made a thousand percent difference to the slope and random error was only one percent, then the VSGLS error to RTPLS error ratio was 1.57 when 100 observations were used, 1.15 when 250 observations were used, and 0.68 when 500 observations were used.

Appendix II. When Estimates use a Log-Linear Form

When a log linear form is assumed, the preliminary regression for when Korea had a fixed exchange rate regime (quarter 3 of 1962 through the 4th quarter of 1997) produced the following results with an *R Squared* of 0.9986 (standard errors are given in parentheses under the estimates: *, **, and *** indicates 90, 95, and 99 percent confident the true coefficient is not zero respectively, Ln = natural log, KY = Korea's GDP, KG = Korea's government consumption, KM1 = Korea's Money Supply, USM1 = US Money Supply, and USG = US government consumption):

Ln(KY) = 1.188 + 0.711 Ln(KG) + 0.179 Ln(KM1) - 0.0133 Ln(USM1) + 0.209 Ln(USG)
(0.0356***) (0.0528***) (0.0656***) (0.0934) (0.178)

The preliminary regression for when Korea had a flexible exchange rate regime (first quarter of 1998 through fourth quarter of 2022) produced the following results (*R Squared* of 0.997).

Ln(KY) = 3.173 + 0.795 Ln(KG) + 0.0688 Ln(KM1) - 0.0551 Ln(USM1) - 0.143 Ln(USG)
(0.00987***) (0.0343***) (0.0163***) (0.00582***) (0.0570**)

Notice that three of the four positive and negative signs on *d*(Korea's GDP)/*d*(US's G) and on *d*(Korea's GDP)/*d*(US's M1) under Korea's fixed then flexible exchange rate regimes do not fit the predictions of the large country IS/LM/BP model presented in Daniels and VanHoose (2004). Furthermore, these results do not fit with any of the small country IS/LM/BP models. Thus using a log linear specification ruined most of the results presented in this paper. To its credit (and in contrast to using a linear form which produced statistically insignificant estimates for *d*KY/*d*KM1), using a log linear form produced positive and statistically significant effects on Korea's GDP for a change in Korea's money supply.

When deciding whether to use a linear or a log-linear specification, one should clearly understand the differences in the meaning of the produced estimates and seriously consider which approach is supported by economic theory. The estimated coefficients for a linear specification are slopes: *d*Y/*d*X. The estimates for a log linear specification are elasticities: %*d*Y/%*d*X. The linear specification assumes that the slopes are constant, the log linear specification assumes that the elasticities are constant. Lines with constant elasticities can look like parabolas or lines with ever increasing or decreasing slopes. Thus the choice between using a linear or a log linear specification totally changes the underlying assumptions for the estimation.

I know of no macroeconomic theoretical models that would predict constant elasticities between

GDP and government spending, money supply, exports, or imports. The classical model would predict that the change in GDP due to a change in government spending, the money supply, exports, and/or imports would be zero (Froyen, 2009). In a Keynesian model, (and IS/LM/BP is a Keynesian model) the change in GDP due to a change in government spending, money supply, exports, or imports are slopes, not elasticities. For example, *d*GDP/*d*G in a Keynesian model is 1/(1-the slope of the relationship between aggregate demand and the income produced by aggregate production). In the simplest Keynesian model, the slope between aggregate demand and aggregate production is the marginal propensity to consume (MPC) (Froyen, 2009). The linear specification used in the main text of this paper fits theory, a log linear specification does not fit theory.

However, if (despite theory) readers prefers to believe the log linear specification, then they are confronted with the implication that under a flexible exchange rate, both US fiscal and monetary stimulus would hurt Korea.