On Economic Growth and Capital Flows

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OSVALDO JOSE A. RAIMONDO FRANCO

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Terry Roe, Adviser

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At a time when the US economy felt itself to be losing out in competition with other countries, especially with Germany and Japan, both in international competitiveness and in general economic performance, it was natural to ask: what do they do that we don't do? Clearly one of the things they do is to save and invest a larger share of aggregate income.

Robert Solow

Reflections on Saving Behavior, October 1982

If capital is perfectly mobile between countries, most of any incremental saving will leave the home country (if it is already a capital exporter) or will replace other source capital that otherwise would be invested in the home country (if it is already a capital importer).

Martin Feldstein,

National Bureau of Economic Research, June 1980

I dedicate my dissertation to my loving wife Carina for her love and patience made it possible.

Abstract

Trade and output in small open economies are more volatile than in larger economies. The study focuses on how country risk shocks and capital flow volatility affect growth of a small open economy under free trade and imperfect capital mobility. Main effects are in physical capital, in households' consumption and trade and output. In contrast with traditional dynamic models, the economy faces idiosyncratic country risk shocks. I present an open Solow model and a Ramsey-Cass-Koopmans growth model for a small open economy with country risk shocks to households' domestic mobile capital and foreign asset portfolio, using an application of the Modigliani's life-cycle hypothesis on household's savings-stock decisions. This study attemps to show the behavior of households saving under stable and volatile environment. Solow's rule on the saving rate, the Friedman's theory of permanent income and Modigliani's hypothesis help to explain households' behavior on saving. To model capital flows, models include a foreign risk-free asset that households have free access to trade internationally. Models show incomplete market for assets as there a single asset available for households' trade. Then, models are calibrated to quantify the short-run fluctuations from shocks and the long run.

Models replicate the empirical regularities well for periods of little capital flow volatility. In periods with greater volatility of capital flows, the Solow model fits data well, and the Ramsey-Cass-Koopmans model well fits physical capital stock and trade. However, the Ramsey-Cass-Koopmans model does not fit consumption and output as actual households do not, or cannot, smooth consumption in periods of greater volatility. I find that country risk shocks constrain investment in physical capital and consumption; output growth co-moves with capital flow changes after 1970s when GDP is pro-cyclical with capital flows. In this environment, trade reversals are associated with sudden stops of capital flows. This study aims to attempt a strong link between empirical and theoretical work, which show robust evidence of the empirical regularities associated to capital flow volatility.

Calibrated models simulate impulse responses to transient country risk shocks to an economy that runs a trade-balance deficit or surplus. They lessen physical capital and output in the short and the long terms while improving exports and trade. Further, capital flow scenarios are compared with a counter example where capital mobility is not allowed, and there is free trade. Main results include advantages and disadvantages of economies that either run a trade-balance surplus or a deficit when facing country risk shocks. Finally, the study suggests enforcing public policies to incentive larger saving rates to lessen country risk shocks impacts..

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1 Introduction

1.1 Saving in Open Economies

In the neoclassical economics, growth depends mainly on investment, saving, technological innovation, and human capital stock. Households' preferences choose to save that is the source for investment in physical capital, which drives economic growth.

In a closed economy, in which international trade and capital flows are not allowed, gross domestic saving is, by definition, equal to physical capital investment in every time t,

$$Gross\ Domestic\ Saving = Investment\ in\ Domestic\ Physical\ Capital \tag{1}$$

In following periods of time, domestic saving accumulates physical capital, economy grows which leads to more physical capital over time. The process, in turn, raises output in the next period, thus developing a virtuous cycle that takes the economy to a dynamic growth process.

In an open economy with free trade of goods and services and capital mobility, capital inflows - as foreign saving - may increase the physical capital formation. Capital outflows - as exports of domestic saving- are invested in foreign assets abroad by resident households, thus lessening investment in domestic physical capital, and thus output growth declines.

The open economy differs with the closed economy as capital flows interacts with domestic saving that is, by definition, investment in domestic physical capital and trade,

$$Gross\ Domestic\ Saving = Investment\ in\ Domestic\ Physical\ Capital\ + Trade \tag{2}$$

Trade is, see equation (7) in the Appendix

$$Trade = -CF + \Delta R + Rn \tag{3}$$

where CF is capital flows; ΔR is the change in central banks' reserves that offset the balance-of-payments imbalance; Rn represents the current transferences and financial services returns. The more an economy is open to trade and capital mobility the more investment is separated to saving. All variables in this study are in units of consumable goods.

For interconnected open economies, the country risk assesses the default risk of the country's sovereign debt, which includes domestic policies and external foreign factors that affect the economy. In turn, country risk affects the households' investment portfolio composition, which for this study, is the set of domestic mobile physical capital and foreign assets abroad. Capital flows equation (3) shows

If country risk increases, households reallocate investments within the portfolio: buy foreign assets, and decrease saving to invest in domestic physical capital. Thus, households transfer capital flows to foreign economies.

The neoclassical economic growth theory explains how sustainable growth paths can be achieved as long as an economy can attain attractive returns for physical capital and foreign asset investments in the long run.

In the study, I focus on the contribution of saving and investment to economic growth sustainability, and on the role of capital flows in domestic physical capital formation and economic growth. This study finds that a positive change in capital inflows (outflows) not only helps increase (reduce) physical capital formation but also affects the national saving share of output and their volatilities.

1.1.1 Three Households' Saving Theories

For a closed economy the domestic saving is equal to Investment in physical capital

$$DS = I \tag{4}$$

Otherwise for open economies, the national saving is

$$NS = I + Trade \tag{5}$$

or in terms of current account[1]

$$NS = I + Current\ Account \tag{6}$$

There are three main theories that attempt to explain the household's saving behavior.

First, Solow (1952) stated that the Saving rate is constant for any time t from observations to saving behavior:

$$Domestic\ Saving\ Rate = \frac{Saving}{GDP} = \text{Constant} \tag{7}$$

Second, Friedman (1957) stated the Permanent Income hypothesis, which he stated: Households save a constant proportion of her permanent income.

Friedman's saving is based on change in the permanent component of income,

[1] Current Account and National Saving definitions are from the National Account Manual, FMI 2003

rather than change in temporary component of income. The Euler motion equation is based on Friedman theory: household's consumption is smoothed out when income fluctuates, in an inter-temporal approach for saving and consumption choice. The Solow's and Friedman's rules are mutually exclusive theories.

Finally, Modigliani (1966) stated the Life-cycle Hypothesis: Savings are proportional to households' wealth in broad classes of mobile physical capital, stocks and bonds that depend on households' age:

$$\text{Precautionary Savings} = \tau \text{ Households' Wealth} \tag{8}$$

There is a difference between saving and savings concepts. Saving in Solow and Friedman theories is a flow variable quantity, in contrary to Modigliani's savings that is a stock variable quantity.

Data for saving and savings sometimes do not fit those three theories, so there is no theory that always fits developed and emerging economies. For the small open Argentinean economy, data show the Solow rules is valid for stable and volatile macroeconomic periods as saving rate is stable for both periods in terms of relative standard deviation.

The Friedman theory does not fit when macroeconomic volatility is great as actual household cannot finance consumption to smooth it and the Ramsey model, which is based on the Friedman's does not predict consumption as in the period 1993-2004 with high capital outflows-to-GDP ratios of 11.0%.

The Modigliani theory applies to capital flows for the Argentinean economy as capital flows are usually precautionary savings in a broad sense, and in this study τ_t is country default risk. Wealth is measured as international mobile capital. I will develop two models, a Solow-Modigliani and a Ramsey-Modigliani for this study.

1.1.2 Capital Flows and Saving

Persistent capital inflows lower domestic saving rate over time in the small open Argentinean economy. In the period 1900-1939, the average saving-to-output rate was 6.8%, and capital inflows accounted for $20.3 billion dollars that financed 64.0% of the actual capital formation. The output growth for the period was 348.1%.

Capital flows are related to international trading of modern technology goods. Some authors described the importation of advanced technology goods as a determinant of growth for small open economies that do not usually develop new technology on their own. I find in this study that capital inflows for Argentinean economy are correlated to imports of capital goods, and intermediate goods. See Figure 12 in Appendix and the section Imported Capital Goods and Capital Inflow Connection below.

The economic framework with capital flows leads to the following questions. What is the role of capital flows in economic growth? How do capital flows interact with saving in the economy; or do capital flows induce volatility in the output and physical capital formation? When is capital flow a determinant of physical capital formation? The key purpose of this study is to address these questions for a small open economy under the modern neoclassical framework.

I use Argentinean data that show how capital flows interact with the real economy. Data experienced macroeconomic fluctuations associated to capital flow volatility. How is that possible?

The Argentinean economy received capital inflows in pounds sterling equivalent to $240.0 billion dollars (in 2004 US dollars) from the United Kingdom in the period 1880-1914 until the onset of the First World War in August 1914, when capital inflows suddenly stopped.

Since year 1914 to 2004, Argentinean residents have been collecting $200.0 billion dollars in investments in foreign assets abroad.[2] In this long period, resident households choose to protect their private wealth with short-lived capital outflows to avoid the effects of government appropriations of private property, of expected local currency devaluations and hyperinflation crises, events that increase country risk. See Kydland et al. (2004) for an economic analysis of the default risk in the Argentina economy. The average of Argentinean country risk measured on a daily basis from January 1993 to July 2007 is 1927.1 that is 19.27 percent points over the US Governmental Bonds. The standard deviation for the period is 2153.6 or 21.53 percent points over the average index 19.27 percent points. The country risk level and volatility reflect the cyclical political, social, and economic crises of Argentina for that period since 1993 when the $EMBI^+$ started to measure the default risk of Argentina on a daily basis. Furthermore, prior to 1993 since 1914 several macroeconomic indicators show similar patterns, such as the Total Factor Productivity that is cyclical like a sinusoidal curve showing mechanical oscillations over and above the horizontal axis since the year 1960 with a HP trend that is zero for every time t. See below Growth Accounting for details.

1.1.3 Empirical Regularities

Capital flow movements in external currency have been a consequence of the country risk volatility as of today, strongly (positive) correlated with GDP, its components, and Total Factor Productivity. Argentina's net foreign asset position in December 2010 equals three times the country's annual GDP in year 2010. This ratio stands in stark to the global assets-to-world average output ratio of 0.70. The significant collec-

[2]Estimation made by the author based on the Balance of Payments data of the period 1880 to 2010. Source: Ferreres (2004)

tion of foreign assets allows large, recurrent, (and sometimes short-lived) movements of capital flows because of external and internal public policies that have periodically shocked the Argentinean economy since 1914. See Appendix, Note 1.

This study shows how country risk shocks hit the economy. Four empirical regularities that are associated with risk shocks are observed in the Argentinean data in the twentieth century, if it is compared with a no-capital mobility economy:

- Capital outflows may induce to reduce physical capital formation and to increase the rate of return. Conversely, capital inflows may induce to increase capital formation and to reduce the rate of return.

- Capital outflows may induce to reduce consumption and to increase the saving rate. Conversely, capital inflows may induce to increase consumption and reduce the saving rate.

- Capital outflows may induce to reduce Gross Domestic Product level and to increase volatility. Conversely, capital may inflows induce to increase GDP level and volatility.

- Trade account reversal follows a capital flow reversal. Small open economies that run a trade-balance deficit may switch to surplus induced by short-lived capital outflows.

The study consists on the empirical evidence of the regularities and the development of theoretical Solow and Ramsey-Cass-Koopmans models that replicate the empirical regularities. Model simulations based on calibrated models will help analyze economic growth recovery under capital outflows, estimate larger saving rates that may reduce capital flows volatility, and estimate the multiplier effects of using intermediate goods as input in the gross domestic production.

1.2 GDP Growth and Capital Flow Volatility in the 20th Century

I identified three distinct periods of the twentieth century for the Argentinean economy that characterize the behavior of the capital flow volatility and the macroeconomy volatility. See Table 3 in Chapter 2.

First, a capital flow volatile period between years 1900-1939 that includes a pivotal period from 1900 until 1914, in which, capital inflows from the UK were significant for the country's economic growth. The World Wide I followed, then the Great Depression started in 1929, and finally the start of World War II.

Second, a capital flow stable Bretton Woods period from 1946 to 1976, and the third period, a volatile period, post-Bretton Woods from 1977 until today. This latter period exhibits the strongest links between capital flows and macroeconomic volatility.

In 1973, when a floating exchange rate regime replaced the fixed exchange rate regime, Milton Friedman et al.(1973) gave testimony before the US Congress on increasing capital flow volatility effects. They presented in the Congress hearing how the floating exchange rate and the increasing capital flow mobility would lead to further output fluctuations in small open, emerging economies.

To describe GDP and capital flows, see Figure 4 in the Appendix that shows data from year 1900 to 2004. Capital flows, and GDP co-moved from 1977, year in which capital flows turned pro-cyclic with GDP. I show capital flow volatility is strongly (positive) correlated with output growth for the small open Argentinean economy.

Figure 7 in Appendix shows the actual GDP deviation from HP trend and actual capital flow deviation from HP trend, which are correlated. It also shows the capital per worker from 1976 to 2004, which is decreasing since 1980 as capital stock continuously decreases and labor force increases from that time.

1.3 Sources of GDP Growth

In this section, I develop a growth accounting exercise to identify growth sources of GDP growth for the 1961-2004 period for the Argentinean economy. Results and capital flow levels and their volatility are shown for time periods in Table 1.

I use a Cobb-Douglas production function for the exercise, a constant returns of scale technology,

$$GDP_t = D\ K_t^{\alpha}[\Omega_t L_t]^{(1-\alpha)} \tag{9}$$

Here, K_t is physical capital stock in period t, L_t is labor force, and $\Omega_t \equiv e^{(1-\alpha)xt}$ is the labor force-augmentation growth rate x_t. The constant α, which is $1 > \alpha > 0$, is the capital share of output, and the constant D.

Total Factor Productivity (TFP_t) is defined as[3]

$$TFP_t \equiv D\ (\Omega_t)^{(1-\alpha)} = D\ e^{(1-\alpha)\ x_t\ t} \tag{10}$$

which is a necessary specification for the existence of stationarity of the GDP_t times series.

Plugging equation (10) into equation (9), GDP_t is

$$GDP_t = TFP_t\ K_t^{\alpha}\ L_t^{(1-\alpha)} \tag{11}$$

Taking logs and derivate both sides of equation (11) respect to time t, the GDP

[3]See Edward C. Prescott & Stephen L. Parente, 1999 for TFP definitions for Cobb-Douglas functions.

growth rate decomposition is,

$$\frac{G\dot{D}P_t}{GDP_t} = \frac{T\dot{F}P_t}{TFP_t} + \alpha \, \frac{\dot{K}_t}{K_t} + (1-\alpha) \, \frac{\dot{L}_t}{L_t} \tag{12}$$

or formulating TFP_t growth rate as a residual,

$$\frac{T\dot{F}P_t}{TFP_t} = \frac{G\dot{D}P_t}{GDP_t} - \alpha \, \frac{\dot{K}_t}{K_t} - (1-\alpha) \, \frac{\dot{L}_t}{L_t} \tag{13}$$

The equation (13) estimates the TFP_t growth rates from GDP_t and inputs K_t and L_t growth rates.

TFP_t growth rates are shown in Figure 7 in the Appendix that shows recurring physical capital building periods and contracting period patterns since year 1960. That is any TFP growing cycle lasts six to seven years, which are followed by a contracting cycle that is shorter, on average four years each. Bad public policies that affect TFP are crucial determinants of the cyclical TFP contractions that in the long term makes the TFP H-P trend equals zero for every time t. Capital outflows are a consequence of bad public policies, so households protect their wealth by tansferring mobile capital to safe and low risk countries.

This study employs a mobile and immobile physical capital stock series developed by Maia (2001), who used the perpetual inventory method from the years 1960 to 2004. Data for the labor force is sourced by the Argentina's Ministry of Economy database from 1960 to 2004.

Table 1 shows the result of the growth accounting exercise. TFP_t and L_t growth rates contributed to GDP_t growth, and they are consistently higher than physical rate since 1961, except for the decade 1970-1979. In each period, an increase of capital outflow is correlated to a decrease in physical capital growth rate, and to a decrease

Table 1: Growth Accounting

Time Period	GDP*	TFP*	Capital Intensity*	Labor Intensity*	Capital Flows**	Capital Flows Volatility***
Years	(%)	(%)	(%)	(%)	(US bn Dollars)	(%)
1960-1969	3.77%	1.74%	0.84%	1.19%	-$0.8	0.76%
1970-1979	2.99%	0.62%	1.36%	1.00%	$2.8	1.48%
1980-1989	-0.70%	-2.21%	0.25%	1.26%	-$51.2	3.75%
1975-2004	1.51%	-0.24%	0.44%	1.31%	-$57.7	3.97%
1990-1999	4.12%	2.10%	0.40%	1.61%	$42.4	4.78%
1993-1998	4.37%	2.40%	0.60%	1.36%	$45.5	5.22%
1999-2004	0.31%	-1.58%	0.10%	1.21%	-$47.0	4.86%
* Average ratio per period						
** US dollars in constant 2004 prices						
*** Standard Deviation (per period) from Hodrik-Prescott trend						

in GDP_t growth; and conversely for an increase of capital inflows.

TFP_t collapsed in the periods 1980-1989 and 1999-2004, in which large capital outflows developed -$51.2 and -$47.0 billion dollars respectively.

TFP_t, GDP_t, and L_t growth rates recuperate in the period 1990-1999 to 2.10%, 4.12% and 1.61% respectively while incoming capital flows are $42.4 billion dollars. It suggests TFP_t growth was the dominant force of the Argentinean GDP_t growth rather than the inputs K_t and L_t growth rates since year 1980.[4] This study aims to uncover the unexplained TFP contribution with capital flows volatility due to bad public policies. However, as this study finds, capital flows impact saving, investment, consumption, and trade, and thus GDP.

Using equation (12) the decomposition of GDP_t growth rate is in Table 1

Figure 3 in Appendix shows the cyclic pattern of TFP_t growth for the period 1961-2004, with an average level close to zero as TFP_t growth in year 2004 is close to the 1961 level. Ten risks shock the economy that reduce TFP_t growth cyclically,

[4]For detail on TFP contribution see Great Depressions of the Twentieth Century by Timothy J. Kehoe and Edward C. Prescott (2007).

which are then followed by TFP_t recuperations. The TFP_t trend results flat over the period, close to zero. For that reason, in Table 2, average TFP_t is 0.46% for the long-run period 1961-2004, with greater volatility 4.75%. The physical capital stock grows 0.65%, and volatility is 0.44%, see also Figure 4 in Appendix. Labor grows at 1.27%, and volatility is 0.76%, see also Figure 5

in Appendix, which is the larger contribution to GDP_t growth 2.38% for the period, see also Figure 6 in Appendix. Labor force input growth has compensated physical capital growth falls in the 1961-2004 period, in which cyclical shocks caused net capital outflows -$53.8 billion dollars. At the time of crisis, the labor force grows as more people join the labor market in production, see labor force data in INDEC (2004)

The other half of GDP_t growth is contributed by equal parts of capital and TFP_t growth rates. See Figure 11 in Appendix.

TFP_t volatility (percent deviation from trend) is the major contributor to GDP_t volatility. Contemporaneous correlation of GDP_t and TFP_t is 0.99 that shows the close relationship between *changes* in TFP_t growth, and *changes* in GDP growth. Physical capital and labor growth correlations with GDP_t growth is 0.40.

Table 2 shows GDP_t growth volatility 5.23% that is higher than Capital flow-to-GDP ratio volatility 3.0%. That leads to the question if country risk shocks and capital flow volatility have overall multiplier effects on the economy and GDP, as it is correlated to volatilities of physical capital formation, consumption, and trade.

1.4 Placing this Dissertation in the Literature

In this section, I summarize the relevant literature on capital flows and current methodologies. I also comment on the related issues of the literature to connect

Table 2: Growth Accounting 1961-2004 Period

	Average Annual Growth Rate	Volatility[1]
Physical Capital Stock	0.65%	0.44%
Labor Force	1.27%	0.76%
TFP	0.46%	4.75%
GDP	2.38%	5.23%
	Net Capital Outflows[2]	CF/GDP Volatility[1]
Capital Flows	-$53.8	3.00%
1 Percent standard deviation from trend		
2 Billion dollars, in 2004 prices		

this study to previous research.

Four main branches of literature on capital flows are identified as they are related to this study. First, Arriazu (2003) and Vegh (2011) described the external and internal factors that determine capital flows. Secondly, Phelps (1962) described the modernization linkage of capital flows and importation of capital goods. Charles Jones (2007) revisiting the production technology with intermediate goods as an input shows a multiplier effect on the final good production generated by the intensity use of intermediate goods.

Third, Hodrick-Prescott (1990) developed a statistical technique to decompose time series in a trend and a deviation about the trend. Their analyses focus on deviations (changes) about the trend rather than on aggregate macrovariable level after the 1980s, which they called business cycles. I will use these thecniques to analyse capital flow volatility. Finally, Long and Plosser (1983) and Kydland and Prescott (1990) promulgated the Real Business Cycles (RBC) theory and the methodology that analysed the trade account and real GDP relationship, which is related to the capital flow issues analysed in this study.

I present a summary for the branches. The first branch starts with Vegh (2011) who describes external and internal factors that pushed and pulled large capital flows from the Argentinean economy in the period 1977-2004. In this period, capital flows were from private residents that accounted for 80% of the total capital flows, and were driven by foreign interest rates. Internal factors for capital flows have been described by Vegh (2011), Calvo, Leiderman and Rienhart (1993), Fernandez Arias (1996) and Taylor and Sarno (1997).

Arriazu (2003) described how capital flows developed from differentials of domestic and foreign interest rate. He also described how a sizable capital outflow reverses a trade-balance deficit into a surplus, regardless of the exchange rate regime. The mechanism causing falls in output by capital outflows (exports of domestic saving) results in an early contraction of the credit supply that leads to a decrease in physical capital investment and private consumption. Output growth contraction follows.

The second branch of literature comes from the linkage of capital flows and imports of capital goods in an open economy. In the periods 1880-1914 and 1993-2004 where capital inflows were strong, the Argentinean data show importation of capital goods that do not appear in capital outflow periods. See Figure 13 in Appendix that shows capital goods importation and capital flows.

Cesaratto (1999) describes how Solow (1957) suggested the link between investment in capital goods and technological progress for closed economies. Later, Phelps (1962), agreeing with Solow (1960), suggested that a higher saving rate leads not only to higher endowments per capita but also to the capital stock modernization.

I show in Chapter 2 how importation of capital goods and intermediate goods are associated with capital inflows. Major economic growth determinants such as saving and investment, and technological progress are closely interrelated to drive economic growth.

The literature on the role of intermediate goods in economic growth started with the input-output models developed by Leontief in the 1930s. Paul Romer (1990) developed a vintage model for heterogeneous aging of the installed physical capital and revisited a production technology with intermediate goods as an input. Different types of capital goods produce intermediate goods (e. g. energy) that are later used by a final good technology.

Later, Charles Jones (2007) revisited Romer (1990) function and developed models incorporating firms that use intermediate goods as inputs to deliver tradable goods. Charles Jones (2011) incorporates intermediate goods into the production technology to take the multiplying effects between intermediate goods and economic growth.

According to Charles Jones (2007), "Intermediate goods are very similar to capital, the only difference is between intermediate goods and capital is one of short-run timing, intermediate goods depreciate fully during the course of production while capital partially depreciates during several periods of production. Both goods are factors of production."

The third branch of the literature is Hodrick-Prescott (1990) that focused on changes of variables, rather on aggregate levels. It is changes in macroeconomic variables, not in aggregate levels, or changes in country risk, which drive changes in the desired stock of capital assets. Recently, Atkins and Pat Kehoe (2008) discuss the changing behavior of short- and long-run variables' changes for different periods of economic history.[5]

The fourth branch is the Real Business Cycle (RBC) theory based on the methodology developed by Kydland-Prescott (1982) and Long and King (1983). Mendoza

[5] As an example, private capital outflows of $43 billion dollars left Argentina from June 2008 to May 2009 as Argentina's country risk, measured by the JP Morgan EMBI+ index jumped 116%, which represented a significant positive change in the foreign asset position owned by residents (EDC 2010). See Appendix, Note 3 for details.

(1991) is the first study that applies the RBC methodology to small open economies. It describes the empirical regularities that RBC models can and cannot reproduce. Data show that GDP and trade move counter-cyclically. Mendoza (1991) shows RBC cannot reproduce the counter-cyclicality of GDP and trade for small open economies in deterministic and stochastic models. The RBC methodology has widely used the inter-temporal approach of the current account to asses the impact of the trade account on GDP. Kydland et al.(1997) applied the RBC theory to the Argentinean economy, but it could not predict the current account volatility that fits data. Neumeyer et al.(2005) using the RBC methodology described how an increasing change of the foreign interest rate could generate capital flows towards the foreign economy searching for a larger interest rate.

The main result of this is GDP growth and interest rate changes are strongly (negative) correlated. Other key drivers of capital flows, such as changes in country risk and speculation, are not included in Neumeyer (2005).

Schmitt-Grohe et al.(2003), following Mendoza (1991) developed four alternative models under an orthodox RCB approach. The four models, using four different specifications of the Euler consumption equation, showed the correlation coefficient between trade and GDP close to zero. Afterwards, Neumeyer et al.(2005) added a demand shock to their RBC model, which is not precisely a neoclassical concept, and obtained a correlation coefficient between trade and GDP slightly better than the orthodox RBC models but still close to zero.

The Roe et al.(2009) pure neoclassical methodology, which I use in the study, provides a good fitting between capital flows, trade and GDP; it shows the trade/GDP counter-cyclical relationship and capital flows/GDP cyclical relationship. Current RCB class models have not predicted such relationships.

Capital Flows in South American Economies

The empirical regularities described in section 1.1 for the Argentinean data are also found in the Brazilian and Chilean economies, where capital flow volatility is great. Arriazu (2003) showed that Brazil's manufacturing production index is strongly (negative) correlated with the current account, which suggests that, the capital flows are correlated with Brazilian production and output.

In Chile, the government adopted a set of counter-cyclical policies to help smooth the macroeconomic fluctuations induced by commodity world prices' volatility. Trade flows associated with the world price of copper generate volatility in the Chilean current account and in the terms of trade. Copper mining valued-added represents 60% of the country's exports in year 2004 (Gutierrez, 2010).

The Chilean policy to offset variances in the world price of copper for the domestic market has been successful in managing the external and internal imbalances. It also contributed to attain a sustainable economic growth path.

Key observations in the literature deal with capital flows and economic growth. Two examples follow. Obstfeld and Taylor (1997) summarized the Latin America economic environment with capital flow mobility:

"In the mid 1970s several Latin American countries, notably Argentina, Chile, and Uruguay opened their capital accounts as part of the exchange-rate based stabilization programs. These programs, flawed by insufficient fiscal stringency, inadequate domestic financial supervision, and inconsistent wage indexation structures, all proved to be unsustainable, and were followed by renewed capital-accounts restrictions."

A second comes from Eichengreen (2004):

"The implications of capital flows for growth and stability is one of the most contentious and least understood issues of our days."

1.5 Description of the Study Plan & Methodology

The study is structured as follows. Chapter 1 encompasses the introduction, the related literature, the objective, and describes the study plan and methodologies used in the study.

Chapter 2 presents empirical evidence on the relationship among capital flow volatility with volatility of aggregate output, saving, consumption and trade. It describes and statistically measures four empirical regularities that are related to capital flows. I use the Hodrick-Prescott (1990) filter methodology to decompose the aggregate macrovariables in a trend and a deviation about the trend to estimate correlation coefficients between deviations in four periods. Evolving the correlation coefficients over time will show the changing relationship between macrovariables. See Note 4 in the Appendix.

The main objective of the study is to construct models of economic growth to replicate the empirical evidence of capital flow impacts on the small open Argentinean economy.

Chapter 3 sets up an open Solow (1952) model and an open Ramsey-Cass-Koopmans (Ramsey (1928), Cass (1975) and Koopmans (1965)) model for the Argentinean small open economy using the modeling methodology developed by Roe et al.(2009). I incorporate a combination of a final good and an intermediate good technology in the models to underline the rigid demand of the combined imports of intermediate plus capital goods, which helps the trade account to reverse when a capital flow reverse.

Roe et al.(2009) developed a modeling methodology that, under a neoclassical framework, integrates national and external accounts in tractable and parsimonious models. It focus on economic growth, and was developed on extensions of the Solow, and Ramsey - Cass - Koopmans models, and on the dual properties between production maximization and cost minimization to characterize the theoretical model equilibrium.

Both models assume households have only access to a risk-free foreign asset, the rate of return of which is exogenously determined abroad. The models share the same assumptions, except for households' consumption modeling. The Solow model takes the typical exogenous, constant over time national saving-to-output rate. The Ramsey model endogenizes the saving rate, and households' behavior are modeled to maximize and smooth their consumption over time.

The dynamic structure of the capital flow movements in the models are described in a small open economy, with exogenous country risk shocks to the resident households' investment portfolio. Mobile domestic physical capital and foreign assets compose the portfolio.

Contemporaneous correlation, which measures the linear association between two random variables is used to measure and assess the validation of the models.

Chapter 4 describes the numerical solution of the Solow and Ramsey models. Model equilibriums are characterized and calibrated to data of the Argentinean small open economy. Linear comtemporaneous correlation is the selected measure for the model fitting to data, which measure the linear association of time series generated by the models to data. NaiChia Li et al.(2006)

Chapter 5 discusses the output of the two models and the Chapter 6 develops four different simulated economies. The simulations consist of an impulse shock of country risk at the start of the model to show the macroeconomic response. The first simulation is an economy under a country risk shock at the start that generates a constant capital outflow until steady state, and the second simulation an economy under a country shock at the start that generates a constant capital inflow. In the third simulation, capital mobility is not allowed.

The fourth simulated economy runs a trade-balance deficit from $t = 0$ that is hit by a onetime, transient country risk shock of a capital outflow in the fourth year of the model. The computer simulation shows that, after the transient country risk shock is absorbed, the economy returns to a lower output path until the steady state. A long-term output gap resultes that is lost forever.

Chapter 6 sets up a counter-factual model that compares the output prediction of a no-flow model with two times series: the actual output and the Solow model that replicates the actual output but a higher saving rate is assumed. The net present discounted cash flows of output differences method compares the benefits and costs of the two simulations between the two alternative output paths. Chapter 6 describes the steady states for the economy and the Jones multiplier effect of using intermediate goods in the final good production. Finally, chapter 6 formulates conclusions of the study.

I leave for future research the generalization of this study findings to any economy, regardless of economy size or stage of development.

2 Empirical Background

2.1 Introduction

I present an empirical background to assess the empirical regularities of economic growth that are associated with capital flows. That is a *change* in capital flow matches a *change* in physical capital investment, and a *change* in GDP. Besides, a trade account reversal occurs if capital flow reverses.

The empirical evidence provides a theory on capital flows, and economic growth to identify and explain the four empirical regularities that are stated in Chapter 1, section 1.1 of this study. The regularities shown are not all independent of each other, so the explanation of each is interrelated with the others. Later, the empirical theory helps, in this study, to specify, explain, and validate the Solow and the Ramsey.

Sala-i-Martin (2002) describes "An important innovation of the new growth literature is that it has brought empirical studies closer to the predictions of economic theory. The neoclassical literature of the 1960s links the theory and evidence by simply mentioning a number of stylized facts (such as the Kaldor facts) and showing that the theory being proposed is consistent with one, two, or perhaps several of these so-called facts.

He adds: "Some of these facts, including the Kaldor facts, did not really come from careful empirical analyses, but they were quoted and used as if they were widely proved empirical facts". See also Hodrick and Prescott (1997), Post war U.S. Business cycles: An Empirical Investigation."

2.2 Data Description

Data contain the following variables. Gross Domestic Product (GDP) in local 1993 prices, and in current prices, secondly external accounts in current US dollars from 1880 to 2004 sourced by Ferreres (2004).

Real aggregate macrovariables for the national accounts from year 1900 are from official data compiled by Ferreres (2004), and at current prices (nominal) values from 1900-1939 by Diaz-Alejandro (1970)[6], and Della Paollera (1988). The nominal values are used in this study to estimate the saving-to-GDP ratios. Della Paolera (1988) estimated the average domestic saving-to-GDP rate of 6% for the period 1900-1939 and 17% percent for 1939-1976. Diaz-Alejandro (1970) provided data prior year 1900.

National Accounts and Balance of Payments from 1900 to 2004 are from the Central Bank of Argentina and Ferreres (2004) in 1993 local currency and current US dollars respectively. I use the GDP deflator and exchange rates to obtain the Balance of Payments in 1993 local currency from Ferreres (2004). The Balance-of-Payments Manual issued by the International Monetary Fund in 1993 sets standard definitions for capital flow and foreign saving.

Maia (2004) developed physical capital stock series for the years 1960 to 2004 at year 1993 constant prices; he used the perpatual inventory methodology. Additional capital series and labor force are sourced by Marie-Ange Veganzones (1997) OECD from 1900 to 1992 and Meloni (1997) to complement Maia (2004) time series. These data are used for the general equilibrium models, and for the total factor productivity analysis. Capacity utilization index for years 1980 to 2008 is from Enrique Bour

[6] Carlos Diaz-Alejandro, an economist while visiting Applied Economics department of the University of Minnesota in late seventies, collected data and researched the Argentinean economy. He wrote a seminal book on the History of Argentinean economy. Dr. Vernon Ruttan, an agricultural professor at the Applied Economics department at that time made significant contributions to the Diaz-Alejandro's research.

(2011), published by the Fundación de Investigaciones Económicas Latinoamericanas Fundacion FIEL. Labor database and population are from the governmental agency Instituto Nacional de Estadisticas y Censos (INDEC), from years 1960 to 2004.

Gross valued added of nine industries at current prices (nominal) were sourced by the Instituto Nacional de Estadisticas y Censos (2004).

Intermediate goods data are provided by the Universidad Argentina de la Empresa (2002) which developed the Leontief input-output matrix for the Argentinean economy. To set up the 1993 initial data of the Argentinean economy model, I used the Global Trade Analysis Project (GTAP) database developed by the Purdue University. Imported intermediate goods and capital goods are by Ferreres (2004).

2.3 Volatile and Stable Periods of Capital Flows

In this section, I describe the volatility of the capital flows and the GDP's aggregate components: investment, saving and consumption to identify stable and volatile capital flow periods from the year 1900 to 2004 for the Argentinean economy.

Macroeconomic fluctuation is defined as the percent standard deviation of aggregate macroeconomic variables while, volatility is defined as the percent standard deviation from the Hodrick-Prescott trend, which is the cyclic component of a variable estimated by the Hodrick-Prescott methodology.

Analysis shows the deviation-from-trend volatility of capital flows is strongly (positive) correlated to the GDP deviation volatility 0.89 rather than it is on aggregate value 0.34. See Table 6.

To describe the relationship of the Gross Domestic Product and the capital flows I also use two statistical tools, an econometric model based on differences of GDP and Capital flows, and a Granger-causality test.

Table 3: Aggregate Saving, Investment and Consumption Shares of GDP

	Average Rates			Average Growth Rates (per cent per annun)					
								Capital	Capital Flows/
	Domestic	Investment	Consumption	Domestic	Investment	Consumption	GDP	Flows*	GDP
Period	Saving/GDP	/GDP	/GDP	Saving/GDP	/GDP	/GDP			Volatility**
Years	(%)	(%)	(%)	(%)	(%)	(%)	(%)	($)	(%)
1900-1939	6.45	11.26	91.18	3.00	2.54	-0.20%	4.10	$20.3	3.54%
1940-1976	19.80	18.29	80.20	2.42	2.71	-0.52%	3.52	$5.1	0.83%
1977-2004	21.00	18.94	79.00	0.32	-0.60	0.31%	1.64	-$74.7	4.11%
1993-2004	19.11	17.41	80.89	6.25	2.07	-1.09%	2.05	-$6.5	4.81%

* Net capital flows in 1993 billion pesos.
**Percent Stardard Deviation from HP trend
Sources: Ferreres(2004) for 1935-2004, and Taylor(1988) for 1900-1934 (page 25) at current prices.

2.3.1 GDP Components and Growth

The Argentinean economy experienced great volatility in GDP, when it is compared to big and small open developed economies as shown by Blejer (2002), Kydland et al. (1997) and Uribe (2011).

This study identifies three clearly distinguished periods of capital flows. A stable capital flow regime occurred in the middle of the century, the Bretton Woods era from 1940 to 1976 during which time a small capital inflow of $5.1 billion pesos occurred. See Figure 9 in Appendix for the Capital flow-GDP ratio in the three periods.

The stable regime fell between two volatile regimes, one before 1940, and another after 1977. Table 3 shows the capital flow volatility and the GDP shares for the three periods and presents the average rate to GDP of domestic saving, consumption, investment, and trade.

In summary, in the period 1900 to 1939 the GDP average annual growth was 4.10%, capital inflows were $20.3 billion pesos and capital flow volatility was high 3.54%. It comprised critical historical events as the economic boom from 1900 until the start of the World War I in 1914. In year 1914, recurring capital outflows started while investment in physical capital significantly reduced for the manufacturing and agricultural industries. During the World Wars I and II, and the Great Depression from 1929 to 1939, Argentina's economic growth was driven by growing agricultural commodities exports to world markets.

Secondly, the stable BReton Woods period from 1940 to 1976, average annual GDP growth was 3.52%, capital inflows were $5.1 billion pesos, and capital flow volatility was relatively low 0.83%.

Finally, the post-Breton Woods era in which the floating exchange rate regime prevailed from 1977 until today. The average annual GDP growth for this era was 1.64%, capital outflows were -$74.7 billion pesos, and capital flow volatility was relatively higher 4.11%, significant higher volatility than in the prior period.

The domestic saving rate increased from a low 6.77% in the first period of capital inflows to 19.8% in the stable period. It then increased to 21.0% as significant capital outflows developed during the third period. Consumption share of GDP decreased for the third period.

GDP annual growth declined from 4.10% in period 1900-1939 to 1.64% in 1977-2004, with lessened growth in domestic saving, investment in physical capital, and consumption while capital flows switched to be pro-cyclical with GDP from counter-cyclic in the previous period 1940-1976. See Table 3.

2.4 Empirical Regularities on Economic Growth

The statistical data on GDP on Table 3, Investment, and capital flow volatility infer that deviation-from-trend values provide stronger links between capital flows and GDP, rather than on aggregate values.

I use the Hodrick-Prescott filter technique to decompose the regularities in a

Table 4: Capital Flows and GDP

Years	1900-1939	1940-1976	1977-2004	1993-2004
GDP Volatility[1]	10.09%	6.49%	8.68%	7.56%
Capital Flows/GDP Rate Correlations	**Counter-cyclical**	**Counter-cyclical**	**Pro-cyclical**	**Pro-cyclical**
Contemporaneous Correlation with GDP[2]	**-0.30**	**-0.26**	0.43	0.34
Percent deviation correlation with GDP deviations[3]	0.63	0.28	**0.77**	**0.89**
Capital Flows/GDP Rate Volatility[1]	3.54%	**0.83%**	4.11%	4.81%
1 Percent standard deviation from trend				
2 Aggregate contemporaneous correlation				
3 Percent Deviation from trend correlation				

trend and a deviation from the trend to analyse the four empirical regularities. I estimate variable correlations and volatility coefficients for each of the macrovariables in deviations-from-the-trend values for the four stable and volatile periods.

The analyses will provide empirical evidence to support the specifications of the Solow and the Ramsey theoretical models in Chapter 3. I use data from year 1900 to 2004 to explain the relationship between capital flows and GDP as well as with saving, consumption, investment, and trade.

2.4.1 Empirical Regularity #1: GDP and Capital Flows

I present an analysis on the relationship between GDP and capital flows and correlation of voaltility of GDP, GDP components, and capital flows.

Pro-Cyclical International Capital Flows with GDP

Table 4 shows correlation coefficients between GDP and capital flows-to-GDP ratio volatilities.

The first observation is aggregate GDP and capital flows were counter-cyclical as reflected by the contemporaneous (negative) correlation coefficients for the first and second periods at -0.30 and -0.26, respectively.

In the two following periods, capital flows turned positive correlated with aggregate GDP at 0.43 and 0.34. That shows a behavior switch of GDP from countercyclical to pro-cyclical direction with capital flows in the period 1977-2004, behavior that prevailed until the end of the study in 2004 in the period 1993-2004.

The direction switch coincides with abandoning the Bretton Woods agreement in 1973, which could have had a key influence in co-moving capital flows and GDP changes in the small open Argentinean economy. Besides, percent deviation correlation coefficient of capital flows with GDP deviation is strongly (positive) 0.77 for the volatile third period, in which the capital flows turned pro-cyclical and increased to 0.89 for the volatile period 1993-2004.

The switch from negative aggregate correlations -0.30 and -0.26 to positive percent deviation from trend 0.77 and 0.89 are shown in periods 1977-2004 and 1993-2004. Note that such deviation correlations are larger than aggregate correlations: 0.43 and 0.34.

Table 4 provides empirical evidence of the main observation of this study: a *change* in GDP is associated with a *change* in capital flows: as capital volatility goes up, GDP volatility rise, and conversely, after the 1970s.

In the first period, volatility of capital flows is 3.54%, and it goes down to 0.83% in the stable period as the GDP volatility co-moves from 10.09% down to 6.48% respectively. When volatility of capital flows turns up to 4.11% in the next period, the GDP volatility goes up to 8.68 %. In the fourth period 1993-2004, GDP volatility increased to 4.81% and GDP decrease to 7.56%. This exception to the rule is shown in Table 5 as investment volatility lessened and trade increased. Capital flow volatility in this period is associated to a larger trade and consumption volatility. See forthcoming Tables 7 & 8.

In summary, every GDP component except domestic saving is strongly (positive) correlated with capital flows at deviation levels after the 1970s. Therefore, it is *changes* in capital flows that are correlated with *changes* in GDP and GDP's components, rather than at aggregate levels, after the capital flows are pro-cyclic with GDP in period 1977-2004.

Pro-cyclicality between capital flows and GDP explains their underlying *co-moving* relationship in the 1977-2004 and 1993-2004 periods. The analysis follows the Hodrick Prescott (1997) empirical framework on U.S. short term (business cycles frequencies) volatilities, which prior to that, Lucas (1981) had emphasized aggregate economic variables to analyse cycles.

GDP Linear Regression

The relationship between GDP_t and CF_t changes for the period 1961-2004 in Table 1 leads to look for output contributors other than physical capital and labor. Capital flows, measured in consumable units, is a candidate to research. The statistical relationship between GDP_t annual changes and capital flows CF_t annual changes can be shown by a least squares regression:

$$GDP_{t+1} - GDP_t = \phi + \varphi \left(CF_{t+1} - CF_t\right) + \varepsilon_t^{''} \tag{14}$$

The regression model estimates a significant (positive) coefficient of $\varphi = 1.34$ with $t = 5.16$ and $p{-}value = 0.0000$ and $\phi = 4161.3$ with $t = 3.16$, $p{-}value = 0.0029$, and $R - squared = 0.41$ for the 1961-2004 period. The statistical relationship between capital flows and GDP is significant for the period 1961-2004 that suggests capital flow movements can be a significant candidate contributor for GDP_t annual changes for the period.

More recently, with the advent of the Asian financial crisis in 1997, large (and short-lived) capital flows were enabling as a result of existing significant savings stock in the global markets, which Bernanke (2005) describes as the savings glut. Moreover, the Asian crisis motivated the search for explaining and modeling the interaction between capital flows and output growth.[7]

Capital Flows and GDP Granger-causality

The Granger-causality test for GDP and capital flow deviations of trend for the period 1900 to 2004 concludes that the null hypothesis that capital flows *do not* Granger-cause GDP can be rejected with p-value $2e^{-07}$at an F-Statistic 31.4. However, the null hypothesis that GDP does *not* Granger-cause capital flows cannot be rejected.

GDP and capital flow deviations from trend co-movement are empirically supported by the regression of the two variables' deviations. The Granger-causality test provides evidence that capital flow deviation can be used to forecast GDP deviations. The opposite direction, Granger-causality from GDP deviations to capital flow deviations can be rejected.

GDP Components and Capital Flow Volatility

Table 5 shows capital flow and GDP components volatilities for five periods. In the period 1900-1939 capital inflow volatility was high 3.54% for the twentieth century. GDP volatility was also high 10.09% as well as investment volatility 50.13%, consumption volatility 6.69% and trade volatility 3.11%.

Capital flow volatility lowered to 0.83% in the next period 1940-1977, investment reduced to 22.62%, consumption to 5.50% and trade volatility to 1.46%. They were the lowest volatility levels for the century while GDP volatility dropped to 6.46%.

In the next period 1977-2004, capital flow volatility grew 4.11%, consumption

[7]The Asian crisis and the savings-glut theory set up a newly integrated framework under the neoclassical theory to explain the role of capital flows in economic growth.

Table 5: GDP Volatility

		GDP Components			
Period	GDP	Consumption	Investment	Trade	CF/GDP
Year	(%)	(%)	(%)	(%)	(%)
1900-2004	8.50	6.58	36.12	2.53	3.05
1900-1939	10.09	6.69	50.13	3.11	3.54
1940-1976	6.49	**5.50**	22.62	1.46	0.83
1977-2004	8.68	7.86	26.69	2.80	4.11
1993-2004	7.56	8.77	23.89	3.60	4.81

volatility to 7.86%, investment to 26.69% and trade volatility to 2.80%. In the period 1993-2004, capital flow volatility increased, and consumption and trade volatilities increased.

The story of capital flow volatility is thought, every time that capital flow volatility grew volatility of GDP and its ingredients increased, and conversely. Depending if the capital flow is a net outflow in 1977 to 2004 or a net inflow in 1900 to 1939, their volatility effects are focused on either investment or trade, see Table 3. Consumption volatility co-moves with capital flow volatility for the four periods.

Capital Flows and GDP Correlations

Table 6 shows GDP components' correlation coefficients with capital flows in aggregate levels, H-P trend, and deviation-from-trend values since year 1977 where capital flows are pro-cyclic to GDP, see also Table 4.

I find evidence that *changes* in capital flows and *changes* in GDP that are measured by the deviation-from-the trend values *co-move* closely since year 1977 to 2004.

Capital flows-to-GDP ratio is strongly correlated with aggregate investment 0.83 and 0.87, and trade -0.83 and -0.91 in the two periods. Aggregate consumption and GDP are weakly correlated in the two periods, GDP correlation coefficient is relative weak 0.43 and 0.34 as weaker consumption correlations increase from 0.36 to 0.43.

Table 6: Capital Flows and GDP Components Correlations

Contemporaneous	Years 1977-2004			Years 1993-2004			1993-2004
Correlation	Aggregate		Deviation	Aggregate		Deviation	Average
CF/GDP ratio with	level	HP Trend	from trend	level	HP Trend	from trend	GDP share
Investment	**0.83**	0.99	**0.78**	**0.87**	0.99	**0.89**	17.4%
Trade[3]	**-0.83**	-0.99	**-0.70**	**-0.91**	-0.99	**-0.92**[1]	1.7%
Consumption	0.36	0.98	**0.80**	0.43	0.99	**0.86**	80.9%
GDP	0.43	-0.99	**0.77**	0.34	-0.99	**0.89**[2]	100.0%
Domestic Saving	0.55	0.99	**0.30**	0.21	0.99	**0.50**	19.1%
1 Counter-cyclical with capital flows							
2 Pro-Cyclical with capital flows							
3 Trade/GDP ratio							

The consumption share of GDP in the Argentinean economy is high 83.0%.

Aggregate domestic saving is weakly correlated with CF/GDP ratio 0.21 compared with GDP 0.34 in the period 1993-2004.

Each aggregate variable correlation coefficient increases from 1977-2004 to 1993-2004, except for domestic saving that decreases to 0.21 from 0.55 and GDP to 0.34 from 0.43.

Aggregate GDP correlation coefficient is relative weak 0.43 and 0.34 as weaker consumption correlations increase from 0.36 to 0.43. The consumption share of GDP in the Argentinean economy is high 83.0%.

For deviation-about-trend correlation coefficients, GDP components are strongly, increasing correlated (see Table 6) with capital flow deviations overtime: 0.77 to 0.98. GDP deviation and investment deviation correlation coefficient are 0.89 which are greater than the aggregate correlation coefficients that of period 1977-2004, 0.83 and 0.43 respectively.

Domestic saving and capital flows are weakly correlated in deviation (and aggregate) levels. However, their correlation coefficients extend over periods as the deviation saving correlation changed from 0.30 to 0.50 in 1977-2004 (and aggregate levels from 0.55 to 0.21 in 1993-2004). In the same period, capital Flows/GDP rate increases from 4.11% to 4.81% (see table 4). The switch in the tendency is also reflected in the aggregate and deviation investment correlation coefficients that are shown in Table 9.

Trade/GDP ratio is counter-cyclical with capital flows in deviation (and aggregate level) for both periods while GDP and capital flows are pro-cyclical. Cyclicality change started in period 1977-2004 if compared with earlier periods, in which they are conversely pro-cyclical and counter-cyclical respectively. See also Table 8.

H-P trend correlations of all variables are strongly correlated 0.99 or -0.99 over the century, this means low-frequency fluctuations of GDP and capital flows are synchronized over time. Thus, this empirical study focuses on percent deviations from the trend that are high-frequency fluctuations of the macrovariables, and the deviation correlations between them.[8] I drop trend correlations in the study as they are 1 or -1 or every couple of variable trends.

2.4.2 Empirical Regularity #2: Investment and Capital Flows

The second empirical regularity is: capital inflow increases are associated to investment increases and saving rate declines.

In closed economies, domestic saving is the single source to finance physical capital investment, differently in open economies, capital flows are either imported or exported savings, such that capital inflows are added to saving and capital outflows are withdrawn from saving. Saving and capital flows in open economies are distinctive macrovariables that interplay to finance investment in physical capital in open economies.

[8] Some authors refer to macroeconomic fluctuations as the business cycle high frequencies. I keep for this study the expression macrovariable deviations about the H-P trend.

Decomposition of Investment Variance

Investment in physical capital is, see Appendix equation (10)

$$I = G_d + CF - \Delta R - Rn \tag{15}$$

where, G_d denotes aggregate domestic saving, CF denotes capital flows, ΔR changes of the central bank's reserves, and Rn, transferences among Argentinean and foreign economies.

The decomposition of the investment variance for equation (15) is

$$Variance\ (i) = \sum Variance.(m_i) + 2\sum Covariance.(m_j, m_i) \tag{16}$$

intermediate good m_i and m_j represent G_d, CF, ΔR and Rn.

Relative variance is defined as the ratio between the variance of the variable of reference and the volatility of investment $\frac{Variance\ (m_i)}{Variance\ (i)}$ and relative covariance by $\frac{Variance\ (m_i)}{Variance.(i)}$. Normalize both sides of equation (16) by $Variance\ (i)$

$$1 = \sum \frac{Variance\ (m_i)}{Variance\ (i)} + 2\sum \frac{Covariance\ (m_j, m_i)}{Variance\ (i)} \tag{17}$$

Relative Standard Variances

Table 7 shows estimates of relative variance of investment decomposed by variance and covariance coefficients of variables of the right side of equation (15). Domestic saving variance is the source of investment variance in the first and second periods with strongly (positive) variances of 0.92 and 0.97. Note that capital flow contributions to volatility were smaller in those periods: 0.21 and -0.03 respectively. Domestic saving variance in the period 1993-2004 decreased to 0.19 while in the first period 1900-1939 was 0.92.

Table 7: Relative Standard Variances

		Variation Sources				
Period	Investment	Domestic Saving	Capital Flow Changes	Reserve Variations	Transferences Rn	Memo: Capital Flows[1]
1900-1939	1.00	0.92	0.21	0.04	-0.18	$20.27
1940-1976	1.00	0.97	-0.03	0.03	0.04	$5.13
1977-2004	1.00	0.64	0.75	-0.28	-0.11	-$74.72
1993-2004	1.00	0.19	1.10	-0.27	-0.02	-$6.45
Memo:						
Closed economy	1.00	1.00	0.00	0.00	0.00	0.00
1 Billions of 1993 local currency.						

Capital flow variance in period 1993-2004 is 1.10, which turns the main source of investment variance rather the domestic saving variance 0.19 for the same period. Capital flow variance increases from 0.21 in period 1900-1039, to 0.75 in 1977-2004, to 1.10 in 1993-2004 as domestic saving decreases from 0.92 in 1900-1939, to 0.64 in 1977-2004, to 0.19 in 1993-2004.

Capital flows in the second period 1940-1976 are smaller $5.13 billion pesos if it is compared with the three others periods and stable capital flows with little volatility 0.83%, see Table 7. It is an open economy in a period of low capital mobility, where domestic saving standard variance is 0.97. Besides, reserve variations and transference relative variances are negligible for the 20th century. The memo shows a closed economy. The economic behavior in this period of partial capital mobility looks much more like a closed economy than an open economy.

Tables 2 to 5 in the Appendix show a breakdown for the variance-covariance coefficient matrices for the four periods.

Co-variance coefficients are negligible except for capital flow and domestic saving. Capital flow interaction with domestic saving is shown in Table 4 in the Appendix in which for the third period, capital flow-saving covariance is 0.37, adding variance to investment 0.73. Co-variance of ΔR and Capital Flows is -0.34 that compensates covariance of capital flow and domestic saving.

In summary, the investment variance decomposition Table 7 shows increasing capital flow variances from 0.21 in the first period, to -0.03 in the second period, to 0.75 in the third period, to 1.10 in the fourth period. At the same time, domestic saving variance decrease from 0.92; to 0.97; to 0.64; to 0.19 as the main source for investment variation for the last two periods. This is a key change in the behavior of capital flows and domestic saving since year 1977 as capital flows turns the greatest contributor to investment variance.

The sourcing pattern of the investment variance has changed significantly from 1900 to today as the role of capital flows, rather than that of domestic saving's, is key for investment variance changes in the small open Argentinean economy.

Granger-causality - Capital Flows and Domestic Saving

Granger-causality test infers the forecasting direction between capital flows and domestic saving. For the period 1900-2004, the Granger-causality test concludes that the following null hypothesis: capital flows do not Granger-cause domestic saving can be rejected based on probability value of 0.005 with F-Statistic 3.80.

The opposite direction: domestic saving does not Granger-cause capital flows cannot be rejected with a p-value 0.34 and F-Statistic 0.93. It is a one-way direction that capital flow lead-lag domestic savings in one year. In section 2.4.1, empirical regularity #1, GDP and Capital Flows, Granger-causality test shows for the period 1900-2004 that capital flow lead-lag GDP changes in one year and only in the direction from capital flows to GDP.

Physical Capital Building and Contraction Cycles

Before analyzing the relationship among capital flows, saving and investment, Figure 10 in Appendix shows growing and contraction cycles of per worker physical

Table 8: Capital Flows, Saving, and Investment

Years	1900-1939	1940-1976	1977-2004	1993-2004
GDP Volatility[1]	10.09%	6.49%	8.68%	7.56%
Capital Flows/GDP Rate	**Counter-cyclical**	**Counter-cyclical**	**Pro-cyclical**	**Pro-cyclical**
Contemporaneous Correlation with GDP[2]	**-0.30**	**-0.26**	0.43	0.34
Percent deviation correlation with GDP deviations[3]	**0.63**	0.28	**0.77**	**0.89**
Volatility[1]	3.54%	**0.83%**	4.11%	4.81%
National Saving	**Procyclical**	**Procyclical**	**Procyclical**	**A-cyclical**
Contemporaneous Correlation with GDP[2]	0.66	**0.99**	0.46	0.21
Percent deviation correlation with GDP deviations[3]	**0.86**	**0.76**	**0.77**	0.48
Volatility[1]	44.1%	18.7%	19.7%	8.4%
Percent deviation Correlation with CF/GDP dev[3]	0.43	0.05	0.48	0.50
Investment	**Procyclical**	**Procyclical**	**Procyclical**	**Procyclical**
Contemporaneous Correlation with GDP[2]	**0.58**	**0.98**	0.62	0.70
Percent deviation correlation with GDP deviations[3]	0.90	0.81	**0.97**	**0.98**
Percent Deviation Correlation with CF/GDP dev[3]	**0.64**	0.45	**0.78**	**0.93**
Percent Deviation Correlation with Saving dev[3]	0.95	0.84	0.81	**0.56**
Volatility[1]	50.1%	22.6%	15.2%	23.9%
1 Percent standard deviation from trend				
2 Aggregate contemporaneous correlation				
3 Percent Deviation from trend correlation				

capital stock in deviations from the trend. Three growth periods are identified, the first one from 1967 to 1971, the second from 1974 to 1981, and the third from 1993 to 2001. Shorter contraction cycles followed each of the growing cycles: first from 1972 to 1974, the second from 1982 to 1986, the third from 1990 to 1992, and the fourth from 2001 to 2004. Growing cycles are associated to capital inflows while contraction cycles to sudden capital outflows, economic crises, country risk increases, intermediate good-to-GDP share increases.

Capital Flows, Saving and Investment Separation

Table 8 below shows aggregate saving level is strongly (positive) correlated with GDP at 0.99 for the period 1940-1977, when capital flows-to-GDP volatility was little 0.83%.

In the first and third periods, saving was positive correlated with GDP at 0.66

and 0.46 respectively. It became a-cyclic with GDP in period 1993-2004, when capital flows-GDP volatility was great 4.81%.

Investment volatility is relative greater than domestic saving volatility, from 50.13% in 1900-1939 period decreasing to 23.89% in 1993-2004. Investment is pro-cycle with GDP in all periods under study. Investment is stronger correlated with GDP deviations from the trend rather than with GDP levels, except for the stable period. Correlation coefficients are 0.90 versus 0.58 and 0.97 versus 0.62 and 0.98 versus 0.70 respectively. Investment is increasingly more positive correlated at high frequencies with GDP, and with capital flow deviations, 0.93 versus 0.56 for the period 1993-2004, see Table 8. The strong (positive) correlation between investment and GDP confirms what neoclassical theory assumes that investment is the main determinant for economic growth.

The patterns of investment correlation coefficients with GDP and capital flows since year 1900 are similar. Since year 1977, there is a synchronization of volatilities of correlations when capital flows/GDP rate turns pro-cyclical from counter-cyclical in since 1977.

The domestic saving deviation is strongly (positive) correlated with GDP deviations for the three periods. It suggests that saving was a determinant for GDP growth at high frequency deviations but not at aggregate levels in volatile periods. As saving deviation correlation declined overtime, reaching 0.48 in 1993-2004, see Table 8, increasing volatility of capital flows in the century constrained the domestic saving financing role.

In the third period, the correlation coefficient of saving deviation with GDP deviations is 0.77 that is equal to the capital flow correlation coefficient with GDP, so both saving, and capital flows are correlated at high frequency deviations in that period. This fact is not observed in previous periods. This is an added suggestion of the change of capital flow behavior after 1977 that volatility of capital flows may affect saving levels.

Even though, volatility of domestic saving is great, 44.11%, 18.73%, and 19.65% for the three periods respectively, saving has weaker deviation (positive) correlation coefficients with capital flows at 0.43, 0.05, and 0.48 respectively.

The degree of imperfect capital mobility can be measured by the national saving-investment correlation that is the separation between saving and investment under capital mobility. Table 9 shows that the national saving - investment percent deviation correlation is 0.56 for the period 1993-2004 under study. Previous correlations shown for other periods are larger, 0.95, 084, 0.81 respectively. The modeled period 1993-2004 is a highly imperfect capital mobility period if compared to previous correlations.

Determinants of Saving and Capital Flows

The relative interdependency of saving and capital flows can be found in their distinct economic fundamentals. Domestic saving's determinants are internal ones, including Harrod's hump-saving and Hicks's intergenerational inheritance as described by Solow (1982)[9].

Determinants of capital flows are external and country-specific factors as countries' interest rates differences, and country risk associated with government default of debt obligations Vegh (2011). The domestic interest rate is the single determinant that shares capital flows and saving.

Summary

The investment deviation is strongly (positive) correlated with capital flows 0.78

[9] Solow (1982) described Harrod's hump-saving as accumulation and decumulation of assets arising because the representative household wants a lifetime consumption pattern that is smoother than its lifetime profile of earnings. A second reason for saving is bequest accumulation to be passed to next generations. Both are domestic determinants of saving. There is no external, foreign reason for domestic saving except for the foreign interest rates.

and 0.93 after year 1977 while former correlation coefficients are weak. The same patterns are observed for the deviation correlation between private consumption and capital flows. See Table 9: they are strongly (positive) correlated after 1977 at 0.79 and 0.89. They are weakly correlated before year 1977 as saving did. I interpret these strongly (positive) correlation coefficients are related to capital flows that are financing investment and consumption.

Capital flows, therefore, constrain the domestic saving role at high frequencies deviations as the major determinant of capital formation and thus for economic growth.

2.4.3 Empirical Regularity #3: Consumption and Capital Flows

The third empirical regularity is a change of consumption level is associated with a change of capital flow levels in the same direction.

Table 9 shows consumption is strongly (positive) correlated with output at aggregate and deviation from the trend levels in every period.

The deviation correlation coefficients of consumption and capital flows were weakly (positive) correlated in the first and second periods at 0.56 and 0.27, respectively. See Table 9.

In the volatile capital flow periods, 1977-2004, and 1993-2004, consumption deviation trend correlation were strongly (positive) correlated with capital flow deviation from trend at coefficients 0.79 and 0.89 respectively. That suggests consumption deviations from trend were *co-moving* capital flows deviation starting in period 1977-2004. When capital inflows increase, consumption increases, and conversely when capital outflows increases, consumption reduces at deviation from the trend since the 1977 year.

Consumption and saving deviations are weaker correlated in the first and second periods: percent deviation of consumption and domestic saving increase from 0.35 to

Table 9: Capital Flows and Consumption

Year	1900-1939	1940-1976	1977-2004	1993-2004
GDP Volatility[1]	10.09%	6.49%	8.68%	7.56%
	Counter-	**Counter-**	**Pro-**	**Pro-**
Capital Flows/GDP Rate Correlations	**cyclical**	**cyclical**	**cyclical**	**cyclical**
Contemporaneous Correlation with GDP[2]	-0.30	-0.26	0.43	0.34
Percent deviation correlation with GDP Deviation[3]	0.63	0.28	**0.77**	**0.89**
Capital Flows/GDP Rate Volatility[1]	3.54%	0.83%	4.11%	4.81%
Consumption Correlations	**Procyclical**	**Procyclical**	**Procyclical**	**Procyclical**
Contemporaneous Correlation with GDP[2]	0.99	1.00	0.98	0.97
Percent deviation correlation with GDP Deviation[3]	0.76	0.95	0.93	0.98
Percent Deviation Correlation with CF/GDP[3]	0.56	0.27	0.79	0.89
Percent Deviation Correlation with Saving[3]	0.35	0.58	0.52	0.30
Consumption Volatility[1]	6.69%	5.50%	7.86%	8.77%
1 Percent standard deviation from trend				
2 Aggregate contemporaneous correlation				
3 Percent Deviation from trend correlation				

0.58, when percent deviation correlation coefficients between saving and capital flows drop to 0.05 from 0.43. The same observation on consumption and saving deviation relation is obtained from Table 9 for the volatile third and 1993-2004 periods, when aggregate saving became a-cyclical with aggregate GDP levels.

An increase of capital inflows is associated with a consumption increase, and at the same time as consumption-to-GDP rate increases, national saving-to-GNI rate decreases. Conversely, an increase of capital outflows is associated with a consumption decrease. As consumption-to-GDP rate declines, national saving-to-GNI increases. See also Table 3.

High consumption-to-GDP share 83% explains why the saving-to-GDP rate in the Argentinean economy was unusually lower compared to similar small open economies for the period 1993-2004, which was stable at 19% with a standard deviation of 1.1%. Consumption level in the period 1993-2004 was high 83% of GDP, in a period when GDP was strongly (positive) correlated with capital inflows at 0.85. For the two remaining periods were 0.91 and 1.16.

For the Argentinean economy, consumption volatility in the period 1993-2004 is higher than GDP in 121 basis points, which may be abnormal for an economy. However, it is observed in any small open economy as Uribe (2011) shows. An explanation for that abnormal volatility can be the method used in Argentina and other emerging economies that estimate consumption as a residual from GDP less investment, and trade. Thus, it may not be a reliable measure. See Kydland et al.(1997).

Summary

The role of capital flows is to increase or to contract consumption, which, in turn, affects saving rate and GDP growth. This statistical relationship is observed at high frequency deviations in small open economies with free trade and imperfect capital mobility.

Table 10: Capital Flows and Trade Reversals

Years	1900-1939	1940-1976	1977-2004	1993-2004
GDP Volatility[1]	10.09%	6.49%	8.68%	7.56%
Capital Flows/GDP Rate Correlations	**Counter-cyclical**	**Counter-cyclical**	**Pro-cyclical**	**Pro-cyclical**
Contemporaneous Correlation with GDP[2]	**-0.30**	**-0.26**	**0.43**	**0.34**
Percent deviation correlation[4]	0.63	0.28	**0.77**	**0.89**
Capital Flows/GDP Volatility[3]	3.54%	0.83%	4.11%	4.81%
Capital Flows Reversals (times per period)	12	14	4	1
Trade Reversals (times per period)	12	14	4	1
Trade/GDP Correlations	**Pro-cyclical**	**Pro-cyclical**	**Counter-cyclical**	**Counter-cyclical**
Contemporaneous Correlation with GDP[2]	0.34	0.20	**-0.14**	**-0.32**
Period trend average	2.79%	1.04%	2.24%	3.06%
Percent deviation correlation[4]	0.52	0.02	**-0.70**	**-0.90**
Trade/GDP Volatility[3]	3.11%	1.46%	2.80%	3.60%
Variation of Centrak Bank Reserves/GDP Volatility[3]	1.48%	1.00%	2.37%	2.80%
1 Percent Deviation from trend				
2 Aggregate contemporaneous correlation				
3 Percent standard deviation (no logs)				
4 Percent Deviation from trend correlation				

2.4.4 Empirical Regularity #4: Trade and Capital Flow Stops

The fourth empirical regularity is a capital flow reversal leads a trade account reversal, which depends upon the intervention of the country's central bank.

Data show that a trade account reversal is correlated to a capital flow reversal. As it depends on the size of the ΔR variation of central bank's reserves, I show alternative outcomes for trade reversals. Figure 22 in the Appendix shows trade account data. The trade-balance deficit turned into a surplus after a capital outflow of 11% of the GDP shocked the economy in year 2000.

Table 10 shows volatility for capital flows and trade-to-output ratios. In the first period, there were twelve trade reversals and twelve capital flows reversals, fourteen in the second period, and four in the third period. The trade reversals caused trade volatility reached 3.11% in the first period, 1.46%, and 2.80% for the last 2 periods respectively. The relationship of trade and output is counter-cyclical after the year

1977, which were pro-cyclical in the first two periods.

Trade volatility is strongly (negative) correlated -.90 to GDP as shown in Table 10. In the second period, the central bank offset the capital flow volatility to 0.83% through a reserve variation volatility of 1.0%. As trade, consumption, and investment volatilities drop in the second period, GDP volatility falls to 6.49%. See Table 9.

Central Bank Policy on Reserves

The trade reversal happens when the central bank chooses to use reserves to offset capital flows. The Argentinean central bank takes as given the data on capital flows and trade accounts, so it has options to deal with trade and capital account imbalances, see equation (18).

It usually has two options: either to offset fully or partly imbalances using central bank's reserves ΔR or not to use any funding so the imbalance will automatically adjust to zero in the medium run, which David Hume (1752) describes.

The Balance-of-Payments for this study is assuming central bank intervenes to counteract imbalances in trade and capital flows for every time t

$$Balance\ of\ Payments_t = (Exp_t - Imp_t) + CF_t - \Delta R_t = 0 \tag{18}$$

Then, capital flow is,

$$CF_t = -(Exp_t - Imp_t) + \Delta R_t \tag{19}$$

To show the link between trade-balance reversals with capital flow reversals, three different outcomes are possible depending if the size of ΔR variation of central bank's reserves is smaller than trade, greater than or equal to trade:

Outcome #1

Suppose there is a deficit in the trade balance and a sudden switch from capital inflows to outflows occurs caused by a country' risk increase. If the central bank intervenes, using reserves such that:

$$\Delta R_t < Export_t - Imports_t \tag{20}$$

Then the trade-balance deficit reverses to a surplus at time t.

Outcome #2

Suppose there is a surplus in the trade balance, and a sudden switch from capital outflows to inflows occurs caused by a country' risk drop. If the central bank intervenes, using reserves such that:

$$\Delta R_t > Export_t - Imports_t \tag{21}$$

Then the trade-balance surplus reverses to a deficit at time t.

Outcome #3

Suppose an economy that is free to trade but capital mobility is not allowed. If ΔR_t is equal to the trade account.

$$\Delta R_t = Exp_t - Imp_t \tag{22}$$

Then, the trade balance remains unchanged.

Table 11: Gross Value-Added per Industry - Average Share of GDP and Volatility

Years		Stable 1940-1976		Volatile 1977-2004		Volatile 1993-2004	
		Average GDP Share[1]	Volatility[2]	Average GDP Share[1]	Volatility[2]	Average GDP Share[1]	Volatility[2]
Gross Domestic Product		**100.0%**	**6.5%**	**100.0%**	**8.7%**	**100.0**	**7.6%**
Tradable Sectors							
	Agriculture	16.6%	13.6%	7.7%	26.4%	6.7%	36.0%
	Mining and Quarrying	1.5%	30.2%	2.4%	34.5%	3.0%	44.7%
	Manufacturing	27.8%	7.1%	24.6%	13.1%	19.7%	18.1%
Total Tradable		**45.8%**	**5.7%**	**34.7%**	**16.4%**	**29.4%**	**24.1%**
Non-tradable Sectors							
	Electricity, Gas, and Water Supply	1.6%	27.0%	2.0%	17.0%	2.1%	12.7%
	Construction	4.8%	22.7%	5.9%	20.2%	5.0%	22.8%
	Commerce, Hotels, and Restaurants	15.9%	9.2%	16.2%	7.1%	16.4%	10.4%
	Financial Intermediation, Real Estate and Business Activities	6.8%	30.3%	16.6%	21.6%	19.7%	20.6%
	Transportation, Storage, and Communications	8.6%	12.2%	6.6%	28.5%	8.3%	18.3%
	Public Administration, Education, and Social Services	16.5%	13.8%	18.1%	17.4%	19.2%	12.5%
Total Non-Tradable		**54.2%**	**4.6%**	**65.3%**	**8.3%**	**70.6%**	**11.8%**

1 Value-added Industry definitions as International Standard Industrial Clasification (ISIC) Rev. 3.1, Feb 2002
2 Percent deviation from H-P trend. Hodrick-Prescott filter methodology.
Data Source: Nominal data for period 1935-2004 INDEC

2.5 Value-Added Volatility per Industry

The purpose of this section is to measure and assess gross value-added industries' volatility in the small open Argentinean economy. It shows the tradable industry volatility doubles the non-tradable industry volatility; macroeconomic fluctuation is mainly focused on trade of goods. Data on gross valued added of nine industries at current prices (nominal) were sourced by the Instituto Nacional de Estadisticas y Censos (2004)

Table 11 shows GDP volatility 7.6% in period 1993-2004 is closer to the non-tradable industries' volatility 11.8%. The non-tradable industry share is 70.6% of GDP. Similar volatitility pattern for GDP and non-tradable industries for prior years. As tradable industries shares rise the non-tradable industries decline and volatility is concentrated in the tradable industries. Table 11 shows gross value-added shares of gross production for nine good and service industries of the Argentinean economy. Share of GDP and its volatility are assessed for tradable and nontradable industries from years 1940 to 2004. Volatility is measured as percent standard deviation from H-P trend.

Gross value-added volatilities of tradable and non-tradable industries are increasing over time since year 1940, regardless of being capital or labor intensive industries. See Table 11. In the period 1993-2004, agriculture volatility was 36%, construction 22.8%, and manufacturing 18.1%. Total tradable good volatility is 24.1%, which doubles the non-tradable good volatility.

The tradable industry-to-gross domestic product shares decline over periods since 1940 from 45.8%, to 34.7% and to 29.4% in 2004. See Table 11. The tradable industry volatility rises from 5.7% in the stable period 1940-1976 to 16.4% in the volatile period 1977-2004, and to 24.1% in the volatile period 1993-2004. Value-added volatilities for the tradable industry are significant greater than the GDP volatility after 1977. In the stable capital flow period 1940-1976, the volatility of the tradable industry is 5.7% similar but greater than the non-tradable industry of 4.6%.

Non-tradable industry volatilities are similar to the GDP volatility for the three periods. It shows total the tradable industry was more impacted by country risk shocks than the total non-tradable industry.

The nontradable industry-to-gross production shares extend over periods, from 54.2% in the stable period 1940-1977 to 65.3% and to 70.6% in the volatile periods 1977-2004 and 1993-2004 respectively.

Based on the tradable and non-tradable good analysis, the study focuses on tradable final, intermediate, and capital goods, and on the trade account, to present a theory of the effects of country risk shocks and capital flow volatility on the small open economy.

The final goods of each industry are used either as intermediate good input for other industries or as final goods for the economy, which are later allocated to domestic

Table 12: Imported Goods Share to GDP

Years	Capital Goods	Intermediate Goods	Consumption Goods
1980-2004	21.8%	63.8%	14.4%
1993-2004	25.4%	56.4%	18.2%
Data Source: Ferreres (2004)			

consumption or exports.

For the Argentinean economy, the domestic intermediate goods-to-industry revenues average rate is 24.6% for the nine industries, sourced by GMAT (1993), University of Purdue. Imported intermediate goods represent on average 50% of the total imports for the 1990s, data sourced by Della Paolera (2003).

The intermediate goods are either used as input in domestic production or traded internationally. They play a key role as an ingredient for economic growth when it complements the the physical capital reduction because of capital outflows. See Figure 10 in Appendix, intermediate good the physical capital stock trend decreases in the Argentinean economy while the labor force trend increases since year 1980 to today, see.

2.6 On the Complementarity of Imported Intermediate and Capital Goods

Table 12 shows imported capital goods, and consumption goods shares of GDP grew to 25.4% and 18.2% respectively, in the volatile 1980-2004 and 1993-2004 periods. However, intermediate goods share dropped to 56.4% from 63.8%.

Table 13 clearly shows what the Table 13 suggests; the correlation coefficient between GDP shares of capital and intermediate goods is strongly (negative) -0.92, so it suggests that both goods are complementary goods as inputs in the final good

Table 13: Imported Intermediate and Capital Goods Share Complementarity

Contemporaneous Correlation	Period 1980-2004
Imported Capital plus Intermediate goods/GDP and GDP	-0.92
Imported Capital goods/GDP Ratio and GDP	0.76
Imported Intermediate goods/GDP Ratio and GDP	-0.72
Data Sources: Ferreres (2004) and Maia (2004)	

production. Note that consumption goods shares of GDP in Table 12 were smaller than other two goods, 14.4% and 18.2% respectively. See Figures 9 and 10 in the Appendix that show the imported capital and intermediate goods and capital flows for the 1980-2004 period.

In Table 14, the GDP share of combined intermediate and capital good dropped to 81.8% from 85.6% and the combined good volatility dropped to only 5.2% from 6.9%, which is significantly smaller than individual volatilities, 23.9%, and 14.9% respectively. The demand of the combined goods as inputs of final production was smoothed over the period 1980-2004 as the average share is 85.6% with a standard deviation 6.5%.

Jones (2011) states: "The phenomenon between both (intermediate and capital) inputs and the linkages that they produced between firms thorough intermediate goods delivering a multiplier similar to the one associated with capital accumulation". Figure 14 in Appendix shows imported intermediate goods and GDP levels co-move during the period.1980-2004.

In the Argentinean economy, the final good technologies are dependent on imported capital and intermediate goods, mainly in manufacturing, which has been an underdeveloped industry for decades as its value-added share of GDP decreased from 27.8% in 1940 to 19.7% in 2004.

Table 14: Imported Capital and Intermediate Goods Shares

Years			Volatile 1980-2004		Volatile 1993-2004	
			Average		Average	
			Share to GDP	Volatility*	Share to GDP	Volatility*
Imported Capital Goods			21.8%	21.1%	25.4%	23.9%
Imported Intermediate goods			63.8%	15.1%	56.4%	14.9%
Imported Capital and Intermediate goods			**85.6%**	**6.9%**	**81.8%**	**5.2%**
Imported Consumption goods			14.4%	47.5%	18.2%	30.3%
*Percent deviation from H-P trend						
Data Sources: Ferreres (2004) and Maia (2004)						

In summary, the more GDP grows the more the imported capital goods-to-GDP share is, and the lesser intermediate goods-to-GDP share is. The two goods are similar in nature as only they differ in their time durability.

The rigid demand of the combined good of imported intermediate plus capital goods helps to make trade reversals. As country risk of a trade-balance deficit economy increases, capital outflows increase, exports rise and as imports keep a smooth demand a trade reversal follows. The theoretical models will feature a rigid demand of importation of the intermediated goods to mimic trade reversals.

2.6.1 Imported Capital Goods and Capital Inflow Connection

See Figure 12 in Appendix, the imported capital goods-to-GDP share, which grew from 19.8% to 43.7% from 1993 to 2004, is associated with capital inflows $53.0 billion dollars because of the lower country risk during the period.

Besides, the correlation coefficient between imported capital goods and the total cumulated capital inflows is 0.70 during the period 1993-2000, there is a close relationship between capital goods and capital inflows.

Table 15 shows capital outflows from year 1980 to 2004; in the first period from 1980 to 1992, capital outflows are -$60.4 billion dollars, and the period from 2001 to

Table 15: Imported Capital Goods and Capital Goods

Years	1980-1992	1993-2000	2001-2004	2004
Capital Flows (US billion dollars)	-$60.4	$53.0	-$54.5	N/App
Imported Capital-Good Avg Annual Growth	2.5%	8.3%	-2.1%	N/App
Share of Imported Capital-Good stock on Total Capital-Good Stock **	11.6% / 11.5%	19.8% /43.7%	44.3% /42.4%	42.4%
Imported Capital Goods-to-GDP Avg Ratio	0.6%	2.5%	1.4%	2.2%
Imported Intermediate Goods-to-GDP Avg Ratio	2.0%	4.8%	3.7%	7.3%
* Inflows + ; Outflows -				
** Start and end points				
Data Sources: Ferreres (2004) and Maia (2004)				

2004, capital outflows are -$54.5 billion dollars. In both periods, the share of capital goods average is 11.5% and 44.0% respectively; there is no correlation between capital goods and capital outflows in both outflows periods. In the period 1993-2004, with capital inflows are $53.0 capital goods grew 8.3%, and the share of imported capital good to the capital stock grew from 19.8% to 43.7%. The goods-to-GDP ratios for both goods are 2.5% and 4.8%, which are greater than the two capital outflow periods.

In summary, capital inflows modernize the capital stock by importing advanced capital goods as Phelps (1962) suggested on the association of increasing imported capital goods and capital inflows. See Figure 12 in Appendix, intermediate good since 1992 until 2000 there were capital inflows and capital goods importation.

On the other hand, importation of intermediate goods is also strongly (positive) correlated 0.97 to GDP for the period 1980-2004 as the gross final good production increases. See Figure 13 in Appendix.

The study shows in Chapter 3 the multiplier effects of use of intermediate goods on gross domestic production and productivity, using theoretical models to simulate economies with and without intermediate goods as inputs. See Figures 13 and 14 in Appendix.

3 The Solow and Ramsey Models

3.1 Strategy for Modeling

The Argentina country is treated as a small open economy that trades real goods and a single risk-free foreign asset available in a foreign country, which yields a given exogenous rate of return. At each instant in time, the small open economy produces two tradable goods, the final goods, and the intermediate goods, which employ neoclassical technologies.

In contrast to traditional theoretical models, households are exposed to idiosyncratic country risks to their mobile wealth portfolio. In modeling the theoretical models in two versions, Solow (exogenous saving rate constant) and Ramsey (endogenous saving). As a simplification, I assume investment as the sole determinant of economic growth in the models because it is the most relevant to analyse the impact of capital mobility in capital formation. I also include technological changes assuming exogenous growth of labor and specific-endowment H in Total Factor Productivity in both technologies. Human capital, technological innovation, and other determinants are not included in this study.

The open Solow (1972) and Ramsey models for a small open economy models country risk and macroeconomic volatility is set up with a final good technology, and an intermediate good technology, both capital-intensive technologies. Goods are tradable internationally, but labor does migrate neither within the domestic economy nor to the foreign country. The non-farm labor in the Argentinean economy was 7.0% of the total labor force for the 1990s, and 10.0% for the 1950s. Manufacturing and Services industries employed most of the labor force, 93.0% and 90.0% respectively.

To model capital flows, the models include a single foreign asset that households can freely trade with an exogenous foreign country.

The Solow model adopts the typical Solow's rule of exogenous, constant saving-to-GNI rate applies over the model lifetime for the Solow model. The open Ramsey - Koopmans - Cass model endogenizes the domestic saving rate as usual. I use the Roe et al.(2009) methodology for developing models' equilibrium characterization, and for the analytical solution of the theoretical models.

The final good technology à la Jones (2011) employs physical capital, labor and an intermediate flow-input (flow variable quantity) that fully depreciates in a year period. The intermediate good input is produced employing physical capital and a specific-endowment H that includes land, infrastructure, institutions, and ports. H is assumed to be a fixed and immobile capital over the model lifetime. Final goods are allocated to domestic consumption and to domestic investment demand, with any excess demand or supply is imported, or exported respectively to a foreign country. The intermediate goods are flow resources with any excess supply or demand exported or imported.

The models assume the tradable final good industry to account for the observation the tradable industries in the Argentinean economy, manufacturing, services, and agriculture, doubles value-added volatility of the nontradable industries yearly since year 1940. See Table 11 in Chapter 2. Non-tradable industry appears not to be affected by the macroeconomic volatility.

The specific-endowment intermediate good technology is adopted in the model in combination with the final good technology, which helps replicate the rigidity of import good demand that is observed when trade balance reverses from a surplus to a deficit and conversely.

Modeled resident households as usual, own domestic and foreign assets and exchange the services of these resources for factor payments, which they allocate to domestic saving and consumption.

Unique to this model is that at each instant in time, households choose to allocate a part of their investment wealth portfolio to the domestic capital market and the remaining part to the foreign asset market abroad in return for a fixed, exogenous rate of return. Such foreign, exogenous return is not necessarily equal to the domestic return on physical capital assets in the domestic economy.

The allocation of household's wealth portfolio is based on the life-cycle hypothesis theory developed by Franco Modigliani (1966 and 2000), which attempts to explain the level of saving in the economy. Household saving according to Modigliani (1966) is a proportion of the total individual wealth as a function of household age.

In the models of this study, the decision governing the allocation of foreign assets at each instant of time the economy is hit by a country risk shock is assumed as a share of the total stock of households' domestic and foreign assets. The assumption defines the allocation of the households' investment portfolio between the domestic physical capital and the foreign asset stocks.

Data show the country risk is a proxy index for the capital flows in the small open Argentinean economy. The country risk used is the $JPMorgan\ EMBI^{+}$ index, which is assumed exogenous to the economy for the models of this study. The JP Morgan Emerging Markets Bond Index (EMBI^{+}) tracks total returns for traded external debt instruments in the emerging countries. It measures the strip spread between the interest rate for external-currency debt over the US Government Bonds, sourced by Global Financial Data, JP Morgan. See JP Morgan (1993).

I use Argentinean economic data for two distinct periods; a capital flows volatile period in 1993-2004 and a stable period in 1940-1951 to show how the Solow and Ramsey models predict the four empirical regularities for both periods.

I choose the capital flow volatile period 1993-2004 that features the four empirical regularities the models fit. A initial stage of capital inflows of US \$ 52.6 billion from years 1993 to 1998, with an output growth of 35.8%. Afterwards, capital outflows of US -$ 47.9 billion from years 1999 to 2002 that help create a trade reversal in December 2001. The capital outflow occurred just before a 300.0% local currency devaluation versus the US dollar and to a sovereign debt default in January 2002, which results in an output drop of 19.5% in the year 2002.

The domestic saving-to-GNI rate during the capital flow volatile period 1993-2004 was 19.1% with a standard deviation of 4.4%. For the stable period 1940-1951, it was 17.1% with a standard deviation of 1.1%.

For the Ramsey model, consumers' behavior is modeled to maximize discounted per worker consumption. The supply side of the Ramsey model is equal to the Solow specification.

The Ramsey model fits the four empirical regularities of consumption, investment, output, and trade for the stable period 1940-1951. The stable period showed Capital flow-to-GDP volatility of 1.1%. See Table 18 Model Validation in Chapter 4 below.

The Ramsey model for the great volatile period 1993-2004 fits investment and trade regularities well, but it does not replicate consumption and output data. Data show Argentinean actual households did not smooth consumption when a great deal of volatile capital flows of 4.81% developed in the 1993-2004 period. Kydland et al. (1997) point out that there were not financial resources in Argentina to allow the actual households to smooth consumption during period 1980-1997. In addition, a sudden capital outflow of 11.0% of the output developed by the end of the year 2001 that reversed the trade balance.[10]

[10] Ahumada (2004) and Uribe (2011) provide empirical evidence that Argentinean consumers could not smooth consumption over the period 1993-2004.

3.2 The Analytic Framework

3.2.1 The Structure of Production

Argentina has historically borrowed abroad to help finance the importation of capital goods and intermediate goods, which would have been otherwise infeasible to finance out of domestic saving. Data on 1990s imports and their interdependence in the supply side lead to the essential feature of using intermediate goods as an input in the country's final good technology. The intermediate input is composed by goods in the models as in the small open Argentinean economy intermediate services input is not significant.

The statistical evidence of the complementarity of imported capital goods and intermediate goods are reflected by the strong positive correlation of both goods.

The Solow and Ramsey models share the structure of production as follows: the first firm consists of a tradable, final good production technology that employs the services of labor L, domestic physical capital K_y, and a tradable, intermediate goods Y_i^d to produce the final goods, Y_f. The final good technology selected is the specified form with intermediate goods by Charles Jones (2007, 2011), constant-returns-to-scale, capital intensive technology as follows. I abstract from time subscripts to simplify the notation whenever there is no ambiguity.

The final good technology is:

$$Y_f(t) = M \ [K_y(t)^{\alpha} \ (\Omega(t)L(t))^{1-\alpha}]^{1-\sigma} Y_i^d(t)^{\sigma} \tag{23}$$

where $\Omega(t)$ is the exogenous augmentation to labor services, given by $\Omega\,(t) = \Omega\,(0)\, e^{xt}$, where $0 > x > 0$ is the exogenous Harrod labor-augmenting technological progress rate of the labor force. The Y_i^d is the intermediate goods used as input in the final good technology. The initial value $\Omega(0)$ is given; constants α, σ,and M;which $0 < \alpha < 1$ is the fraction of the physical capital endowment, $0 < \sigma < 1$ is the inverse of the elasticity of substitution between the intermediate goods and the capital and labor inputs, and M a constant.

The labor force, L is assumed to follow $L(t) = L(0)e^{nt}$ path, where n is the exogenous growth rate of the labor force. M is a constant, the product $M\ [\Omega(t)]^{(1-\alpha)(1-\sigma)}$ is the factor productivity for time t. Note $(1-\alpha)(1-\sigma)$ is the multiplier effect of using intermediate goods in the technology, which increases the steady-state level of Y_f.[11]

The second firm is engaged in producing non-durable intermediate goods, which is a flow resource (a flow variable quantity that completely depreciates in a year period, e.g, chemicals) that is tradable. The intermediate good production technology employs capital K_i, and a fixed, immobile, specific-endowment H that includes natural resources, land, institutions, infrastructure, and ports. The specific-endowment H allows for the intermediate good function equation (24) to remain open under a broad range of parameters and initial conditions, see Roe et al. (2007).

For the purpose of this study, I excluded labor from the capital-intensive intermediate technology to make the model more parsimonious and tractable[12]as farm labor in the small open Argentinean economy is 7.0% of the labor force for the 1993-2004 model period and 10.0% for the 1950s. Labor is immobile within the economy and between countries since the 1960s. Data sourced by INDEC (2004).

The capital-intensive production tecnology of intermediate goods Y_i is the follow-

[11] Charles Jones (2011) has revisited the intermediate goods technology which has the property that increases the steady- state level of production through a multiplier to the factor productivity.

[12] According to Irz et al (2005) "(T)he use of Cobb-Douglas production function in agriculture is not ideal as there is evidence that, for instance, the elasticity of substitution between labor and land is less than one. Unfortunately, the model is not tractable when using CES or nested CES forms in the two sector model."

ing Cobb-Douglas function:

$$Y_i(t) = N\ K_i(t)^{\beta}\ [\mathcal{B}(t)\, H]^{1-\beta} \tag{24}$$

where K_i is physical capital, H is a fixed, immobile, and specific-endowment capital, composed by land, infrastructure, institutions and ports, $\mathcal{B}(t)$ is the exogenous augmentation to services of H, N is a constant, the product $N\mathcal{B}(t)]^{(1-\beta)}$ is factor productivity, and constant β is the share of the physical capital endowment to Y_i.

$\mathcal{B}(t)$ is assumed to be given by

$$\mathcal{B}(t) = e^{\gamma t} \tag{25}$$

where γ is the exogenous rate of technological change of H.

Combining both technologies in the model will help to replicate actual smooth importation level over the 1990's that will show when a trade reversal occurs.

Capital Market There is a risk-free, domestic capital market for K_y, and K_i, so the domestic market clears at r^k rate. Depreciations $\delta_y = \delta_i$ are equal, called δ.

Specific-endowment H can be rented at rate π^h among firms within the intermediate good sector. The specific-endowment H is assumed fixed so it has no depreciation and is immobile capital.

The Final Good Firm's Problem

I present two approaches to define the firms' and the households' problems for a clear communication. They are the typical primal and the production and cost dual approaches as follows.

Given prices $\{w, r^k\}$, the firm produces final, tradable goods and solve the profit maximization problem by choosing the allocation $\{L, K_y, Y_i^d\}$ of labor, physical capital and the intermediate good output Y_i that is consumed by the final good technology such that, for every time t

$$\pi_f \equiv Y_f - wL - r^k K_y - Y_i^d \tag{26}$$

Subject to:

the Cobb-Douglas production technology

$$Y_f = M\{(K_y)^\alpha(\Omega L)^{1-\alpha}\}^{1-\sigma}(Y_i^d)^\sigma \tag{27}$$

where π_f is the profits for the final goods; L is labor force, which is assumed to be inelastically supplied by households. K_y denotes physical capital rented to firms at r^k; $\Omega = \Omega(0)e^{nt}$ is the exogenous augmentation to labor services in the final good technology; and n is the exogenous growth rate of the labor force. The price for the tradable goods p is normalized to 1 for simplicity. M is a constant, the product $M\Omega^{(1-\alpha)(1-\sigma)} > 0$ is the factor productivity for the final good production.

Firm's Problem using Production and Cost Duality

This is the alternative statement of the Firm's problem using the dual approach.

Final Good Tecnology

Given the rental rates of factor given, the maximization of the final good profits equation (26) subject to equation (27) can be expressed as per the duality properties as the minimization of cost

$C(\hat{w}_t, r^k_t, p)\ \hat{y}^f_t$, in per effective worker values,

$$C(\hat{w}_t, r^k_t, p)\ \hat{y}^f_t \equiv \underset{(\hat{k}_y,\ \hat{y}^d_i)}{Min}\ (\hat{w}_t + r^k_t \hat{k}_{y,t} + p\hat{y}^d_{i,t}) : \hat{y}_{f,t}\ \leq \hat{y}_{f,t}(\hat{k}_{y,t}, \hat{y}^d_{i,t}) \tag{28}$$

Subject to the Coob-Douglas equation (27).

where $C(\hat{w}_t, r^k_t, p)$ is the cost per unit of final good production per effective worker and it is calculated from the minimization problem expressed by the right-hand side equation (28). Price for tradable goods is normailized to 1 after derivating respect to p..

As an example, the profits expressed in the dual approach, plugging cost per unit into equation (26), are

$$\hat{\pi}_{f,t} = \hat{y}^f_t - C(\hat{w}_t, r^k_t)\ \hat{y}^f_t \tag{29}$$

The Intermediate Good Firm's Problem

Given prices (w_t, r^k_t), the firm produces intermediate goods and solve the profit maximization problem by choosing the allocation (K_i, Y_i) such that, for every time t [13]:

$$\pi_{i,t} \equiv Y_{i,t} - r^k K_{i,t} - \Pi_t\ H \tag{30}$$

Subject to

the intermediate good technology

$$Y_{i,t} = N\ (K_{i,t})^\beta\ (\mathcal{B}_t\ H)^{1-\beta} \tag{31}$$

[13] Profit includes the rental rate for a unit of specif endowment H. Later, the value added of mobile and inmobile capital of the intermediate technology will be used instead of profit, see equation (32) below.

where, π_i is the profit for the intermediate goods; Y_i is a tradable intermediate good; K_i is domestic physical capital stock owned by households used in the intermediate good technology; H is a fixed, exogenously given specific-endowment owned by households; r^k is the return rate to K_i; Π is the rental rate per unit of H; p the price of the tradable intermediate goods, which is normalized to 1. $\mathcal{B}$ is the exogenous augmentation to services of the fixed factor H, constant N, and the product $N\ \mathcal{B} > 0$ is the factor productivity for the intermediate good production.

The intermediate good using Production and Cost Duality

Given the capital rental price r^k, the maximization of value added of the intermediate good production equation (31) before the rental of specific-endowment H is defined as, in per effective worker terms:

$$\hat{\pi}^h(r_t^k, p)\ H \equiv \underset{(\hat{k}_i)}{Max}\{p\ \hat{y}_{i,t}(\hat{k}_{i,t}; \mathcal{B}H) - r_t^k \hat{k}_{i,t}\} \tag{32}$$

where $\pi^h(r_t^k, p_t)$ is the per effective worker rental rate per unit of H required for the rental market to clear. The value added of intermediate good production $\pi^h(r_t^k, p_t)\ H$ before the total rental of H is calculated from the maximization problem expressed by right-hand side of equation (32).[14]The underling assumption in equation (32) is that in equilibrium the maximization of profits equation (32) is zero, so the value added before the total rent of H is equal to the total rental rate of H.

Assuming differentiallity, by Hotelling's lema the gradients of $\pi^h(r_t^k, p_t)$ the partial equilibrium supply and derived capital demand per economy-wide effective labor,

[14]The United Nations System of National Accounts (1993) defines the operating surplus to refer to the above value added of H. It is the operating surplus before taking the rental factor on specific endowment H.

e.g.[15],

$$\frac{\partial \hat{\pi}^h(r_t^k, p_t)}{\partial r_t^k} H = \hat{k}_{i,t} \tag{33}$$

The Structure of Saving and Consumption

Saving and Investment

The investment in domestic physical capital is related to the national saving and the current account balance as follows

$$National\ Saving = Investment + Current\ Account \tag{34}$$

The current account is,

$$Current\ Account = Trade + Rn + r^f A^f \tag{35}$$

by combining the output equation and the Balance of Payments,

$$CF = -Trade + \Delta R \tag{36}$$

Plugging the previous equation into current account

$$Current\ Account = -CF + \Delta R + Rn + r^f A^f \tag{37}$$

where CF is capital flows, central bank's reserves ΔR used to offset capital flows, Rn is for the transferences and $r^f A_f$ the foreign returns to resident households that are included in the current account.

The total foreign asset stock is denoted by A^f at each instant in time, which is the

[15] See Roe et al. (2009) page 85

net holding of foreign asset stock owned by residents. A^f can be positive or negative. The convention for A^f is, if $A^f > 0$ the net stock is an asset, if $A^f < 0$, the net stock is a liability.

To simplify handling ΔR in the model, I assume that a positive (negative) variation of the central bank's reserves ΔR for the domestic economy is equivalent to a capital outflow (inflow), therefore the equation of motion of foreign assets is, see equation (133) below for the deduction of it

$$Capital\ Flows = -\dot{A}^f + r^f A^f \tag{38}$$

The previous equation shows that a *change* in A^f develops capital flows, direction of which will be defined by the change in the Argentinean country risk.

Finally, plugging previous equation into equation (37) current account is

$$Current\ Account = \dot{A}^f + Rn \tag{39}$$

The national saving, plugging capital flows into the equation (37) is,

$$National\ Saving = Investment + Current\ Account \tag{40}$$

Plugging Current Account into national saving

$$National\ Saving = Investment + \dot{A}^f + Rn \tag{41}$$

For simplification, as Rn is negligible in the Argentinean national accounts,

$$National\ Saving = Investment + \dot{A}^f \tag{42}$$

Investment in Physical Capital

The total investment in physical capital is the variations of domestic physical capital of both technologies and their depreciation

$$I = \dot{K}_y + \dot{K}_i + \delta(K_y + K_i) \tag{43}$$

where δ is the depreciation rate of the physical capital.

Plugging investment I into national saving (42), national saving accumulates total physical capital K and A^f,

$$G_n = \dot{K}_y + \dot{K}_i + \delta(K_y + K_i) + \dot{A}^f \tag{44}$$

The equation of national saving (44) is an alternative formulation of equation (2), which expresses that households' saving is the source of mobile physical capital stock, its depreciation, and changes in foreign asset holdings that are owned by resident households. All variables in the study are expressed in units of consumable output Y_f.[16]

Capital Flows and Households' Mobile Investment Portfolio The model assumes free trade of goods and capital mobility between the small open economy and the exogenous foreign price-setter economy.

The only foreign asset available to households is a risk-free foreign asset, which is withdrawn from (or deposited in) A_t^f, which is the total assets accumulated abroad. In an open economy, a *change* in A_t^f generates capital flows, that is, if $\dot{A}_t^f > 0$, then households buys assets in the local market and send them abroad; capital outflows

[16]As households also own the non-tradable, inmobile, endowment H, which is assumed constant over time, the accumulation $\dot{H} = 0$.

hit the economy. If $\dot{A}_t^f < 0$, households withdraw assets from A_t^f and takes them back home, amount that is accumulated to the physical capital stock as a result of country risks hit the economy.

The total household's wealth is assumed to be K_t^{total}, the mobile investment portfolio K_t plus the immobile, fixed H,

$$K_t^{total} \equiv K_t + H \tag{45}$$

where the endogenous household's mobile investment portfolio, denoted by K_t, is the sum of the endogenous domestic physical capital, $K_{d,t} = K_{y,t} + K_{i,t}$ plus the endogenous foreign asset stock A_t^f as follows,

$$K_t = K_{y,t} + K_{i,t} + A_t^f \tag{46}$$

The allocation of the total mobile wealth K_t in the foreign asset stock A_t^f in the foreign country is assumed to be a proportional to the JPMorgan EMBI$^+$ Index[17]:

$$A_t^f \equiv -EMBI^+ \ K_t \tag{47}$$

If country risk is defined as τ_t such is $\tau_t = -EMBI^+$

$$A_t^f \equiv \tau_t \ K_t \tag{48}$$

where K_t is the endogenous, mobile wealth owned by households, and τ_t is the coun-

[17] This assumption is based on the observation of the households' investment behavior in the data of the Argentinean economy. Allocation is assumed to be linear. It follows the Modigliani (1966) life-cycle theory on the formation of individual precautionary savings, which is proportional to household's wealth. Precautionary savings is a stock variable which is different to saving that is a flow variable quantity.

try risk given by the JP Morgan EMBI$^+$ index, which is assumed exogenous in the models of this study for the Argentinean small open economy. By this equation, households' investment behavior endogenizes capital flows in the models as A_t^f and K_t are endogenous and τ_t is exogenous. This equation also assumes that annual foreign assets stock A_t^f is limited to the mobile capital K_t level rather than total wealth $K_t + H$ level for every time t.

Every time that the EMBI$^+$ increases, τ_t is negative, and there is a capital outflow. Otherwise, if EMBI$^+$ decreases, τ_t is positive, and there is a capital inflow. If $\tau_t = 0$, then $A_t^f = 0$ and K_t is equal to domestic physical capital K_d. The range for idiosyncratic shocks are $-1 < \tau_t < +\infty$ and $\tau_1 \neq 1$, for capital inflows the range is $0 < \tau_t < +\infty$, and $\tau \neq 1$ in order to have $K_d = 0$; for capital outflows τ_t is $-1 < \tau_t < 0$.

Equation (48) is a crucial assumption for the model and is based on empirical evidence on households' behavior; *changes* in country risk are closely associated with *changes* in capital flows during the period 1977-2004 when capital flows are procyclical to GDP_t. The greater the country risk change is the greater the capital outflow change is, and the greater the foreign asset stock A_t^f is.

Any time there is a change in the country risk, households reallocate their mobile investment portfolio K_t composition buying (or selling) foreign assets. The remaining K_t is allocated to domestic physical capital $K_{d,t}$ that is then split to capital for final good production $K_{y,t}$, and for intermediate good production $K_{i,t}$, so that $K_{d,t} = K_{y,t} + K_{i,t}$.for every time t.

Imperfect Capital Mobility

The Argentinean small open economy shows imperfection of capital mobility as the immobile capital that cannot be collateral is four times the mobile capital. Imperfection is introduced in the model through the immobile, specific-endowment H that helps the model's replication of the convergence to the long run according to empirical evidence. If the capital mobility is perfect, the model shows higher rates of convergence than those observed empirically, according to Barro et al.(1997).

The mobile capital K_t can be used as collateral for capital flows, but the immobile H cannot be collateral even though is physical capital Per assumption, H cannot be financed by foreign borrowing, reason by which the economic growth models are featured with imperfect capital mobility. Barro (1997) mentioned that not all investments can be financed through perfect financial markets. The key distinction between $K_{d,t}$ and specific-endowment H is whether the cumulated goods serve as collateral for borrowing in world markets. A broad class of capital includes physical capital and foreign assets the ones that can be used as collateral rather than H that cannot be.

The imperfection degree of openness of a small open economy can be measured by the ratio of mobile K_t over total wealth that is defined mobile and immobile $K_t + H$ such as

$$\zeta_t \equiv \frac{K_t}{K_t + H} \tag{49}$$

Capital mobility is perfect when the ratio equals one, imperfect when ratio is less than one. There is evidence the small open Argentinean economy has $\zeta_t < 1$ reflected in the capital series by Maia (2004) as the immobile broad capital class is four times the mobile capital that is on average $\zeta = 25.0$ % for the 1960-2004 period [18]

Alternatively, the degree of imperfect capital mobility can be measured by the saving-investment correlation that is the separation between saving and investment under capital flows. Table 9 in chapter 2 shows that the national saving - investment

[18] Barro et al. (1997) shows that imperfect capital mobile is a feature for open economies that reflects restrictions to capital mobility. When imperfect capital mobility is modelled, the model has a better convergence in the long run if compared to perfect and no capital mobility.

percent deviation correlation is 0.56 for the period 1993-2004 under study. Previous correlations showed larger correlations 0.95,0.84,0.81 for other periods respectively..

Capital Rates of Return

Firms, in this economy, rent physical capital from households at r^d.

The saving and investment market, equation (43), is risk-free and competitive and clears, in equilibrium, at the endogenous rate r_t^k that equals the net return on physical capital $r_t^d + \delta$ for every time t

$$r_t^k = r_t^d + \delta \tag{50}$$

The rate of return of the foreign asset r^f is assumed exogenous and fixed for every time t. Households arbitrage the difference between the endogenous r_t^d and the exogenous, fixed r^f through buying and selling foreign assets to look for better returns. For the Ramsey model, the exogenous, constant foreign return is set equal to the steady-state rate of return $r^{k,ss}$ of domestic capital when steady-state country risk $\tau^{ss} = 0$:

$$r^f = r^{k,ss} = \rho + \delta + \mu\ x \tag{51}$$

The Households' Income Budget Constraint

The households' income budget constraint is deduced from the dual expressions of Gross National Income (GNI) as follows.

The GNI, is the total factor payments that households receive,

$$GNI \equiv wL + r^k K_d + \Pi^h(r^k)\ \mathcal{B}\ H + r^f A^f \tag{52}$$

where w, is wages; L is labor force; r^k the rate of return for K_d ; H is the specific-endowment; $\Pi^h(r^k)$ is the rental rate of H; A^f are the total foreign assets abroad, and r^f is the exogenous rate of return of the foreign assets. The term $r^f A^f$ may be positive (receiving from the foreign economy) or negative (paying to the foreign economy).

Plugging the dual $GNI = G_n + Q$ in the left-hand side (52), where G_n is national saving and Q is consumption,

$$G_n + Q = wL + r^k K_d + \Pi^h(r^k)\ \mathcal{B}\ H + r^f A^f \tag{53}$$

Replacing $G_n = \dot{K}_d + \delta K_d + \dot{A}^f$ equation (44)[19]in the left-hand side, and defining the total households' mobile investment wealth portfolio as the domestic capital and foreign assets $K = K_d + A^f$, the households' income budget constraint for the Solow and the Ramsey models is expressed as a function of K_d,

$$\dot{K}_d + \delta K_d + \dot{A}^f = wL + r^k K_d + \Pi^h(r^k)\ \mathcal{B}H + r^f A^f - Q \tag{54}$$

By algebra,

$$\dot{K}_d = wL + r^k K_d(1-\delta) + \Pi^h(r^k)\ \mathcal{B}H + r^f A^f - \dot{A}^f - Q \tag{55}$$

Replacing $\dot{K} = \dot{K}_d + \dot{A}^f$ and $K_d = K - A^f$,

$$\dot{K} + \delta(K - A^f) = wL + r^k(K - A^f) + \Pi^h(r^k)\ \mathcal{B}\ H + r^f A^f - Q \tag{56}$$

[19] The Domestic Saving for this economy model is equal to $\dot{K}_d + \delta K_d$, which is expressed in physical capital.

By algebra,

$$\dot{K} = wL + (r^k - \delta)(K - A^f) + \Pi^h(r^k)\ \mathcal{B}\ H + r^f A^f - Q \tag{57}$$

The households' income budget constraint in aggregate values as a function of K is

$$\dot{K} = wL + (r^k - \delta)\ K + \Pi^h(r^k)\ \mathcal{B}\ H + (r^f - r^k + \delta)\ A^f - Q \tag{58}$$

The income budget constraint in terms of total aggregate wealth K, replacing $A^f = \tau K$, equation (48) and equation (50) $r^d = r^k - \delta$

$$\dot{K} = wL + r^d\ K + \Pi^h(r^k)\ \mathcal{B}\ H + (r^f - r^d)\ \tau\ K - Q \tag{59}$$

where $r^d = r^k - \delta$ is the rate received by households to rent physical capital K_d to firms, and δ is the depreciation rate of the domestic physical capital, K_y and K_i. The foreign asset has no depreciation by assumption. This equation assumes that the relative prices of consumables, physical capital and specific-endowment H are always fixed at unity.

No-arbitration of rental rates between mobile and immobile capital Note that the income budget constraint equation (59) could have been written as, for the case of no exogenous technical change B

$$\dot{K} = wL + r^d\ (K + p_h H) + (r^f - r^d)\ \tau\ K - Q \tag{60}$$

or in terms of domestic capital K_d

$$\dot{K} = wL + r^k[K_d(1-\delta) + p_h H] + r^f A^f - \dot{A}^f - Q \tag{61}$$

where r^d is the rental rate of per unit of K and H, and p_h is the unit price of the immobile capital H.

It follows that the optimal allocation of assets to maximize returns to investments requires that agents be indifferent, at the margin, between their holdings of capital K_d and H assets at each instant in time.[20]

The objective is, given r_t^k and Π_t^h, to look for a unit price $p_{h,t}$ that makes equations (55) and (61) equivalent. The results for every time t is

$$r_t^k = \frac{\Pi_t^h}{p_{h,t}} + \frac{\dot{p}_{h,t}}{p_{h,t}} \tag{62}$$

The unit price $p_{h,t}$ of capital H makes no-arbitration between the rate of return r_t^k of mobile capital K_d and the rental rate Π_t^h of immobile capital H in the domestic capital market. If this condition (62) did not hold, optimizing investors could exploit the arbitrage opportunity and move investments out of H and into capital K_d and vice versa.

The equation (62) in per effective worker for every time t, is

$$r_t^k = \frac{\hat{\pi}_t^h}{p_{h,t}} + \frac{\dot{p}_{h,t}}{p_{h,t}} + (x+n) \tag{63}$$

The Solow and Ramsey Households' Problems The Solow and Ramsey models share the households' budget income equation (59), and the assumed allocation of total assets K equation (48). The single difference between models is the consump-

[20] For a presentation of no-arbitrage between assets, see Roe et al. (2009) for a comprehensive explanation.

tion choice behavior of households. The Solow model assumes the saving behavior (and consumption) is a fixed proportion of the contemporaneous income, the typical constant, exogenous saving-to-GNI rate while the Ramsey model assumes an inter-temporal choice problem of current and future consumption. The typical Euler equation adjusted by country risk substitutes the Solow's rule in the Ramsey households' problem.

Solow Model: Rule on Household Saving Rate

The economy consists of infinitely-living households each of which has equal family size $L(t)$. Households choose to save a fixed proportion of the contemporaneous income, by algebra in equation (66)

$$G_n = \bar{g}_n \; GNI \tag{64}$$

where $\bar{g}_n$ is the Solow (1972) rules on national saving rate that is constant for every time t based on empirical observations of the behavior of household saving

$$\bar{g}_n \equiv \frac{National\ Saving}{GNI} = \text{constant} \tag{65}$$

Households allocate the Gross National Income, GNI, in consumption of final goods Q, and in national saving G_n, such that for every time t

$$GNI = Q + G_n \tag{66}$$

The households' income budget constraint

The income constraint equation (59) normalized by effective worker ΩL from equation (27) results

$$\dot{\hat{k}} = \hat{w} + \hat{k}(r^k - \delta - x - n) + \hat{\pi}^h H + \hat{a}^f(r^f - r^k + \delta) - (1 - \bar{g}_n)g\hat{n}i \tag{67}$$

The gross national income per effective worker $g\hat{n}i$ is

$$g\hat{n}i = \hat{w} + r^k\hat{k}_y + r^k\hat{k}_i + \hat{\pi}^h H + \hat{a}^f r^f \tag{68}$$

As $\hat{k}_y + \hat{k}_i = \hat{k} - \hat{a}^f$

$$g\hat{n}i = \hat{w} + r^k(\hat{k} - \hat{a}^f) + \hat{\pi}^h H + \hat{a}^f r^f \tag{69}$$

By algebra

$$g\hat{n}i = \hat{w} + r^k\hat{k} + \hat{\pi}^h H + \hat{a}^f(r^f - r^k) \tag{70}$$

Plugging $g\hat{n}i$ into income budget constraint equation (67)

$$\begin{aligned} \dot{\hat{k}} &= \hat{w} + \hat{k}\ (r^k - \delta - x - n) + \hat{a}^f(r^f - r^k + \delta) + \hat{\pi}^h H - \\ &\quad [\hat{w} + +r^k\hat{k} + \hat{\pi}^h H + \hat{a}^f(r^f - r^k)] + \bar{g}_n\ g\hat{n}i \end{aligned} \tag{71}$$

By algebra

$$\dot{\hat{k}} = -\hat{k}\ (\delta + x + n) + \hat{a}^f(r^f - r^k + \delta) - \hat{a}^f(r^f - r^k) + \bar{g}_n\ g\hat{n}i \tag{72}$$

the households' income constraint is

$$\dot{\hat{k}} = -\hat{k}(\delta + x + n) + \hat{a}^f\delta + \bar{g}_n\ g\hat{n}i \tag{73}$$

The Solow Households' problem:

Given the endowment stream of Gross National Income per effective worker $g\hat{n}i_t$, the foreign rate of return r^f, and the country risk shocks $\{\tau_t\}_{t\epsilon[0,\infty)}$ to the mobile households' wealth, the plan $\{\hat{w}_t, r_t^d\}_{t\epsilon[0,\infty)}$ that is wage, and the rate of return to domestic capital; the constant national saving constant rate $\bar{g}_n$, infinitely-living resident households choose a plan of consumption and foreign asset stock $\{\hat{q}_t, \hat{a}_t^f\}_{t\epsilon[0,\infty)}$, such that for every time t

$$\hat{q}_t = (1 - \bar{g}_n)\ g\hat{n}i_t \tag{74}$$

Subject to:

1) the households' budget constraint equation (67)

$$\dot{\hat{k}} = \hat{w} + \hat{k}(r^k - \delta - x - n) + \hat{\pi}^h H + \hat{a}^f(r^f - r^k + \delta) - \hat{q}_t \tag{75}$$

2) the assumed allocation of endogenous foreign asset stock withdrawn from the households' mobile investment wealth portfolio, and

$$\hat{a}_t^f \equiv \tau_t\ \hat{k}_t \tag{76}$$

3) the gni_t

$$g\hat{n}i = \hat{w} + r^k\hat{k}_y + r^k k_i + \hat{\pi}^h H + \hat{a}^f r^f \tag{77}$$

where r^f is the rate of return paid to domestic resident households for holding foreign assets $\hat{a}^f$ while $\hat{a}^f < 0$ is a liability that generates a service payment from the households to the foreign economy.

The variables $\hat{k}_t$ and $\hat{a}^f$ are endogenous and country risk τ_t is exogenous. It is analog to the Solow's rule, where the saving rate is exogenous and constant over time whereas national saving and GNI are endogenous.

The Ramsey Model: Endogenizing the Saving Rate

The Ramsey model endogenizes domestic saving, so the exogenous, constant saving rate Solow rule is replaced by the Euler equation that results from the maximization of the discounted felicity function per worker.

The Ramsey's model assumes the economy consists of a society of a large number of households each of which has equal family size $L(t)$ and is an infinitely living dynasty. The maximization of the discounted present value of future flows of the society's felicity function $u(q_t)\ L(t)$ with regard to the per worker consumption over the infinite horizon plan:

$$\max_{(q_t)} \int_0^\infty u(q_t)L(t)e^{-\rho t}dt \tag{78}$$

where q_t is consumption per worker, and ρ is the subjective discount rate of time preference of the society's felicity function, which is assumed constant over time. It requires the assumption on the existence of perfect financial markets to fund the inter-temporal choice between consumption in the present and future time. In contrast with imperfect financial markets that restrict agents from transferring desired wealth among states.

The felicity function per worker is assumed to be:

$$u(q_t) = \frac{q_t^{1-\mu} - 1}{1 - \mu} \tag{79}$$

which is increasing in q_t and concave, which is $u'(q_t) > 0$ and $u''(q_t) < 0$, which reflects the desire of the consumer to smooth increasing consumption over time.

The parameter μ denotes the inverse of the elasticity of inter-temporal substitution, which $\frac{1}{\mu}$ measures the inter-temporal consumption allocation and the households' willingness to smooth consumption over time when μ is constant. So, there are two features in the maximization of the felicity function, the inter-temporal choice between consumption and saving reflected by μ, and the discount factor ρ, which is $0 < \rho < 1$ and constant over time, that gives the discounted value of the annual felicity value over time.

Plugging $u(q_t)$, and $L(t) = L(0)\ e^{nt}$ into the $U(t)$ expression, where n, the exogenous labor force growth and normalizing $L(0) = 1$, complete the expression of the maximization of the discounted felicity function per worker.

The Ramsey households' problem

Households maximize the social's felicity function that is the optimization of the inter-temporal trade between consumption in the current time and in the future in per worker terms. The maximization problem is solved in per effective worker terms to avoid non-autonomous equations when possible, thus to simplify the numerical solution.

The inter-temporal optimization assumes the existence of perfect financial markets to fund smoothing consumption, which is a critical assumption for modeling country risk shocks and capital flow volatility. The resulting Euler equation of motion reflects such maximizing behavior without liquidity constraints. In case an economy violates the assumption, we cannot infer anything about the optimization problem theorem. We do not already have an optimization theorem with liquidity constraints, which would be researched in the future.

The Ramsey households' problem is:

Given prices $\{w_t, r_t^d, r^f\}_{t\epsilon[0,\infty)}$ and the country risk shocks $\{\tau_t\}_{t\epsilon[0,\infty)}$, resident households choose to allocate per worker consumption, national saving, and foreign asset stock $\{g_{n,t}, q_t, a_t^f\}_{t\epsilon[0,\infty)},$ that maximize the discounted present value of the social's felicity function $U(t) \equiv \frac{[(q_t)^{1-\mu}-1]}{1-\mu}\ L(t)$ respect to per worker consumption q_t, under perfect financial markets, such that

$$\underset{(q_t)}{max} \int_0^{+\infty} \frac{{q_t}^{(1-\mu)} - 1}{1-\mu}\ L(0)\ e^{-(\rho-n)t}\ dt \tag{80}$$

Subject to:

1) the households' budget constraint equation (58)

$$g(q_t, k_t, a_t^f, t) \equiv w_t + (r_t^d - n)\ k_t\ + (r^f - r_t^d)\ a_t^f + \hat{\pi}_t^h\ \mathcal{B}_t\ H - q_t = \dot{k}_t \tag{81}$$

2) the assumed allocation of foreign assets,

$$a_t^f = \tau_t\ k_t \tag{82}$$

3) A given initial capital

$$k_t(0) = k_0 > 0 \tag{83}$$

4) and a transversality terminal condition[21]

$$\underset{t->+\infty}{lim}\ k_t\ e^{-\int_0^t (r_t^d\ -\ n)\ dv} = 0 \tag{84}$$

Analytical Solution for Euler Equation

[21] This basically states that in the limit either there has to be no units of the state variable k_t left over ($\underset{t->+\infty}{lim}\ k_t = 0$) or if there are units left over, then their value has to be zero in terms of maximizing utility ($v_{t=+\infty} = 0$).

The Hamiltonian operator solves the Ramsey households maximization problem, in per worker terms,

$$H(t) = \frac{(q_t^{1-\mu} - 1)}{1-\mu} e^{-(\rho - n)\ t} + \upsilon_t\ g(q_t, k_t, \tau_t, t) \tag{85}$$

where q_t the control variable, k_t is the state variable, $g(q_t, k_t, \tau_t, t)$ the budget income constraint, and υ_t is the Lagrange dynamic multiplier.

Subject to

the households' budget income constraint,

$$g(q_t, k_t, \tau_t, t) \equiv \dot{k}_t = w_t + (r_t^d - n)\ k_t\ + \tau_t\ (r^f - r_t^d)\ k_t + \hat{\pi}_t^h(r^k)\ \mathcal{B}_t\ H - q_t \tag{86}$$

the given initial condition of the per worker total assets for t=0,

$$k_t(0) > 0 \tag{87}$$

and the terminal transversality condition,

$$\lim_{t->+\infty} k_t\ e^{-\int_0^t (r_t^d\ -\ n)\ dv} = 0 \tag{88}$$

that means that in the limit when time t tends to infinity,

k_t cannot tend to infinity.

Solving the Hamiltonian Operator The first order conditions in per worker terms respect to two state variables q_t, k_t,and the multiplier υ_t necessary for an interior solution are according to the present-value Hamilton optimality conditions[22],

$$\frac{\partial H_t}{\partial q_t} = 0 \tag{89}$$

$$\frac{\partial H_t}{\partial k_t} = -\dot{\upsilon}_t \tag{90}$$

$$\frac{\partial H_t}{\partial \upsilon_t} = \dot{k}_t \tag{91}$$

The multiplier υ_t represents the shadow-value at time $t = 0$ of having an additional unit of the state variable k_t at time t.

These optimality conditions applied to our problem deliver

$$\frac{\partial H_t}{\partial q_t} = q_t^{-\mu} e^{-(\rho-n)t} - \upsilon_t = 0 \tag{92}$$

$$\frac{\partial H_t}{\partial k_t} = \upsilon_t\{(r_t^d - n) + \tau_t\ (r^f - r^d)\} = -\dot{\upsilon}_t \tag{93}$$

$$\frac{\partial H_t}{\partial \upsilon_t} = \dot{k}_t \tag{94}$$

Solving for q_t, from $\frac{\partial H_t}{\partial q_t}$ (92)

$$q_t^{-\mu} e^{-(\rho-n)\ t} = \upsilon_t \tag{95}$$

taking logs to both sides of equation (95)

$$-\mu\ ln[q_t] - (\rho - n)t = ln[\upsilon_t] \tag{96}$$

and derivate equation (96) respect to time t

$$\mu\ \frac{\dot{q}_t}{q_t} + (\rho - n) = -\frac{\dot{\upsilon}_t}{\upsilon_t} \tag{97}$$

[22] See Barro et al. (1997), Mathematical Appendix, page 604

From $\frac{\partial H_t}{\partial k_t}$ equation (97)

$$-\frac{\dot{\upsilon}_t}{\upsilon_t} = (r_t^d - n) + (r^f - r_t^d)\ \tau_t \tag{98}$$

The left-hand side of equation (97) is equal to the

right-hand side of (98), then

$$\mu\ \frac{\dot{q}_t}{q_t} + (\rho - n) = (r_t^d - n) + (r^f - r_t^d)\ \tau_t \tag{99}$$

By algebra in the previous equation

$$\frac{\dot{q}_t}{q_t} = \frac{1}{\mu}\{(r_t^d - \rho) + (r^f - r_t^d)\ \tau_t\} \tag{100}$$

The equation of motion is called the Euler equation that expresses the optimal per worker consumption growth path as a function of the rental rate r_t^d, the exogenous ρ discount factor, the exogenous foreign rate of return r^f, the exogenous country risk τ_t shocks, and μ;it is not a function of state variable k_t.

Normalizing per worker consumption q_t into per effective worker units $\hat{q}_t$,

$$\hat{q}_t \equiv \frac{q}{e^{\ xt}} \tag{101}$$

By derivation of equation (101) respect to time t,

$$\frac{\dot{\hat{q}}_t}{\hat{q}_t} = \frac{\dot{q}_t}{q_t} - x \tag{102}$$

Plugging the previous equation (102) into the equation (100), the Euler equation in per effective worker terms is:

$$\frac{\dot{\hat{q}}_t}{\hat{q}_t} = \frac{1}{\mu}[(r_t^d - \rho - \mu\ x) + (r^f - r_t^d)\ \tau_t] \tag{103}$$

The Euler equation (103), the households' income budget constraint (86), and the transversality condition (88) that are in per effective worker terms constitute a system of three differential equations that is the solution of the households' problem. The required transversality condition is simply satisfied whether the endogenous $r_t^d > \rho+n$ for every t.

Transmission Mechanism of Country Risk Shocks to Consumption

To assess the impact of country risk τ_t shocks on consumption, the Euler equation (103) is split in two terms. A direct effect $(r_t^d - \rho - \mu\ x)$, which is the Euler equation for an economy that does not allow capital flows, and an indirect effect $(r_t^d - r^f)\ \tau_t$ that transmits τ_t shocks to consumption growth path.

The two terms distinctly affect the households' consumption growth rate as follows:

The consumption growth rate rises for every time t if

$$(r_t^d - \rho - \mu x) + (r^f - r_t^d)\tau_t > 0 \tag{104}$$

The first term in the left-hand side of equation (104) is the consumption growth for an economy with no capital flows. It is positive if the rental rate exceeds the discount rate plus the adjusted Harrod labor-augmenting technological progress μx. So the net rental rate $(r_t^d - \rho - \mu x)$ must be greater than the adjusted-difference τ shock in the left-hand side of inequality (104) for consumption to grow. See the Euler equation

(103).

The indirect effect term $(r^f - r_t^d)\ \tau_t$ includes an endogenous forcing function $(r^f - r_t^d)$ for the shock τ_t which sets the transmission mechanism of the country risk shocks to the consumption growth path. The size of the difference between the foreign rate of return and the domestic rental rate $(r^f - r_t^d)$ amplifies (or contracts) the effect of the exogenous τ_t shocks to the consumption growth path.

Analyzing how country risk affects consumption growth path implies to study the Euler equation (103). If the country risk increases a capital outflow is generated, k_d falls, so the rental rate r^d increases, and the size of the difference $(r^f - r_t^d)$ drops (as the exogenous r^f is constant). Then, the indirect effect contracts the effect of τ_t on consumption growth.

Alternatively, if the country risk decreases, a capital inflow is generated, k_d rises, so the rental rate r^d decreases. The size of the difference $(r^f - r_t^d)$ increases (as the exogenous r^f is constant), then the indirect term amplifies the effect of τ_t on consumption growth.

Prolonged capital inflows will keep the r^d decreasing, so the size of the difference will be $r^f\tau_t$ that is the maximum amplifying effect of τ_t shocks. Alternatively, prolonged capital outflows, will keep the rental rate r_t^d increasing and the size of the difference $(r^f - r_t^d)$ will tend to zero, so consumption growth will be protected from any τ_t shock.

In the simple case of pegging rates $r_t^d = r^f$, at any time t, the rate difference is zero and the τ_t shock effect on consumption is null. In this environment, if there is a capital flight to a safe country with lower (or stable) country risk, the effect of τ_t (either capital outflows or inflows) is fully neutralized. The consumption growth rate equation (103) becomes the Euler equation without country risk shocks, no capital mobility.

In general, there are three conditions for the slope of the consumption path to be positive or negative in equation (103):

- If it is greater than zero

$$(r_t^d - \rho - \mu x) + (r^f - r_t^d)\ \tau_t > 0 \tag{105}$$

  consumption growth is positive $\frac{\dot{\hat{q}}_t}{\hat{q}_t} > 0$.

- If it is equal to zero

$$(r_t^d - \rho - \mu x) = -(r^f - r_t^d)\tau_t \tag{106}$$

  consumption growth is zero $\frac{\dot{\hat{q}}_t}{\hat{q}_t} = 0$.

- If it is less than zero

$$(r_t^d - \rho - \mu x) + (r^f - r_t^d)\ \tau_t < 0 \tag{107}$$

  consumption growth falls.

Country Risk effects on Capital Rates When an economy is volatile as capital flows are coming and going, domestic interest rates are relatively low in the actual economy. The minimum interest rate is in indicator that shows how low the United States and European Union's domestic interest rates are, and why they can be so low without affecting the smoothing of consumption growth in the current environment. In the Argentinean economy real interest rates are also low in periods of capital flows high volatility. Capital flows volatility reduces the minimum rate so interest rate are lower than in a no-capital mobility economy.

Solving equation (106) for r^d, a minimum value of $r^d_{t,}$ exists, such that is required to allow consumption to grow $\frac{\dot{\hat{q}}_t}{\hat{q}_t} > 0$ for every time t. By algebra in equation (106), the endogenous rental rate should be, for every time t, greater than the value of the exogenous right-hand side term of equation (108) for small open economy:,

$$r^d_{\min}(\tau_t) \equiv \frac{\rho + \mu x + r^f \tau_t}{1 + \tau_t} \tag{108}$$

For a large country risk shock (capital inflows) $\tau_t > 0$, which tends to infinity, the $r^d_{t,\min}$ is

$$\underset{\tau \, -> \, +\infty}{lim} r^d_{\min}(\tau) = \underset{\tau \, -> \, +\infty}{lim} \frac{\rho + \mu x + r^f \tau_t}{1 + \tau_t} = \rho + \mu x = r^f - \delta \tag{109}$$

which is constant and equal to the steady-state rental rate of capital $r^{d,ss}$ that in turn equals the foreign rate of return r^f less depreciation δ, equation (55)

For a no-capital mobility economy $\tau_t = 0$, the $r^{d,}_{t,\min}$ is equal to equation (109)

$$r^d_{t,\min}(0) = \rho + \mu x \tag{110}$$

which is equal to the steady state rental rate for an economy without capital mobility. For the models, see section 4.2.1 Incomplete asset markets in this study, I assume $\tau^{ss} = 0$ no capital mobility in steady state, so $r^{d,ss} = r^d_{t,\min}(0)$.

Under capital inflows. that is $0 < \tau_t < +\infty$, the minimum rental rate $r^{d,}_{t,\min}$ for the Argentinean economy is bounded between the exogenous external rate $r^f - \delta$ and the exogenous behavioral parameters $\rho + \mu x$. This is a measure for the impact of country risk $\tau_t > 0$ on the optimal consumption path volatility under perfect financial markets. So that a smaller gap $r^f - \ \rho + \mu x$ reduce the volatility vulnerability of country risk shocks greater than zero. However, the consumption growth is narrowly bounded for risk shocks $\tau_t > 0$ associated with prolonged capital inflows

Otherwise, under capital outflows, that is $-1 < \tau_t < 0$, $r^d_{t,\min}$ is not bounded from below, and $r^d_{t,\min}$ is always greater than $r^{d,ss}$. Associated capital outflows induce consumption growth to fall. Besides, low rental rates $r^d < \rho + \mu x$ of capital are associated with consumption depression equation (107) under perfect financial markets. However, the associated drop in consumption growth is even greater if imperfect perfect markets exist as it appears to happen in the Argentinean economy for the 1990s as Kydland et al (1997) who point out that there were not financial resources in Argentina to allow the actual households to smooth consumption during period 1980-1997.

The relation of $r^d_{\min}$ for capital inflows, outflows and no mobility will show how each capital regime affects the capital rental rate. For an open economy, plugging r^f equation (55) into $r^d_{\min}$ equation (108) results

$$r^d_{\min}(\tau_t) \equiv \frac{\rho\ (1+\tau_t) + \mu x\ (1+\tau_t) + \delta\tau_t}{(1+\tau_t)} \tag{111}$$

By algebra,

$$r^d_{\min}(\tau_t) = \rho + \mu x + \frac{\delta\ \tau_t}{(1+\tau_t)} \tag{112}$$

Country risk changes always decrease the exogenous minimum capital rate if compared to a closed economy rate.

The last term $\frac{\delta\tau}{1+\tau}$ in the previous equation (112) is the difference with the equation (110) with no country shocks.

For example, for capital outflows, where $\frac{\tau}{1+\tau} < 0$, it implies that

$$r^{d,closed}_{\min} > r^{d,outflows}_{\min} \tag{113}$$

consumption grows for every time t.

And for capital inflows, where $\frac{\tau}{1+\tau} < 1$, it implies that

$$r_{\min}^{d,closed} > r_{\min}^{d,\inf lows} \tag{114}$$

consumption grows for every time t.

The relation of capital rates is as $r_{\min}^{d,\inf lows} > r_{\min}^{d,outflows}$

$$r_{\min}^{d,closed} > r_{\min}^{d,\inf lows} > r_{\min}^{d,outflows} \tag{115}$$

A closed economy requires the highest minimum rental rate, which is greater than for capital inflows and outflows. Capital outflows allow lower capital return rates that the two other capital regimes to maintain consumption growing. Avoiding lower rental rates than $\rho + \mu x + \frac{\delta\ \tau_t}{(1+\tau_t)}$ would reduce the effects of country risk shocks and the associated capital outflows on consumption growth.

In the case for imperfect capital markets, where there is a wedge between mobile capital rates $r^d = \eta_t\ (r^k - \delta)$ where $0 < \eta_t < 1$, the rental rate received by the households will be lower than in perfect markets where equation (50) holds. That lower rental rate could be lower than the minimum $r_{\min}^d$ so consumption will fall. It depends on the parameter η_t if it is close to zero.

Note that a public policy that addresses the three internal parameters ρ, μ, and x would reduce the vulnerability of the economy to country risk shocks, and their capital inflow and outflow movements.

The country risk as a tax to consumption

Increasing country risk shocks $\tau > 0$ require a greater minimum rental rate to smooth consumption as if it were no capital flows, equation (112). Negative country risk shocks $\tau < 0$ operate as a tax on consumption growth, which reduces the per worker consumption growth over time if it is compared with a no-capital mobility scenario. See Model Simulations, Chapter 4, consumption and saving.

Also, if the financial markets are perfect and regardless if capital flows are incoming or outgoing, the consumption growth rate is positive as long as the endogenous rental rate r_t^d is higher than the exogenous minimum rate $r_{\min}^d$.

Under imperfect financial markets

If imperfect financial markets exist in the actual economy, the optimal consumption growth path may not possible for real households. They do not have access to fund the inter-temporal trade between current and future consumption.

Therefore, the smooth growth path generated by the Euler equation in the models under perfect financial markets may not replicate data. Data show that, after a large capital outflow in 2002, consumption declines while the smooth path of the Ramsey modeled consumption continues growing during the late 1990s. See Figure 31 in the Appendix.

The benefit to consume

The transmission of the τ_t shocks can be also evaluated using an alternative formulation of the Euler equation (103), by algebra

$$\mu\ (\frac{\dot{\hat{q}}_t}{\hat{q}_t} + x) + \rho = r_t^d + \tau_t\ (r^f - r_t^d) \tag{116}$$

The left-hand side of equation (116) represents the benefit to consume that is not affected by τ shocks and is composed of two terms. The discount factor parameter ρ represents the benefit to consume in the present rather than in the future; the rate $\frac{\dot{\hat{q}}_t}{\hat{q}_t}$ is the consumption growth rate; x is the Harrod labor-augmenting technological progress rate; and μ is the inverse of the elasticity of inter-temporal substitution.[23]

The right-hand side of equation (116) is composed by the rental rate that households receive to rent capital to firms, and the term $\tau\ (r^f - r_t^d)$, where τ shock affects the rate difference. Equality of the equation (116) means that households are indifferent between to consume and to save.

The consumption growth rate increases if the right-hand side of equation (116) increases by a positive τ_t, that is a country risk shock. In this case $\tau_t > 0$ operates as a subsidy to the consumption growth. Otherwise, consumption growth declines if the right-hand side of the same equation decreases by a $\tau_t < 0$ that is a country risk shock that generates a capital outflow. The $\tau_t < 0$ operates as a tax to consumption growth.

Harrod Labor-Augmenting Technological Progress Impact

When financial markets are perfect, an improvement in Harrod labor-augmenting progress rate x induces an increase in the benefit to consume, in the left-hand side of equation (116). Therefore, it neutralizes the negative τ_t shocks on consumption growth.

In periods of high capital outflow volatility, in which households do not (or cannot) smooth consumption as there are no funding for it, equality of equation (116) does not hold. Then the effect of Harrod labor-augmenting technological progress improvement on consumption growth is ambiguous.

At times of large τ shocks, households may desire to proceed with capital outflows, so saving rate rises and consumption drops; thus equality may not hold.

In the Argentinean small open economy, when capital flow volatility is higher,

[23] This is a conceptual extension of the consumption benefit under no capital flows mobility in Barro et al. (2004).

there is empirical evidence that the discount factor ρ and the risk adverse μ are highly volatile, so they add further volatility to the equation and that equality does not hold. There is also evidence that the perfect financial markets assumption does not hold in periods of high capital outflow volatility in the 1990s. Kydland et al.(1997) who point out that there were not financial and loans resources in Argentina to allow the actual households to smooth consumption during period 1980-1997.

The Ramsey model of this study does not replicate real households' behavior. Households do not smooth consumption growth when capital flow volatility is relatively greater during the 1990s.

Open economies with higher Harrod labor-augmenting technological rate are less sensitive to capital flow volatility in stable volatility periods than in no-capital mobility economies. Even where financial resources allow smoothing consumption growth. Moreover, when there are large capital inflows, and the modeled and actual rental rate r^d tend to decline, a higher Harrod labor-augmenting technological progress rate increases the $r^d_{\min}$ value hence it partially improves the consumption growth rates because it may not allow the r^d to be lower than the minimum rental rate. Otherwise, actual consumption growth further declines while modeled consumption growth continues growing.

The Solow consumption path is not affected by the financial market assumption because modeled households are not assumed to behave as consumption smoothers as in the Ramsey model. Solow's households take as given the constant, exogenous saving rate and are assumed to consume a fixed proportion of the contemporaneous incomes every period.

3.3 The External Balance

3.3.1 Capital Flows and Trade

The definition of capital flows used in the study is according to the International Monetary Fund Manual, 5th edition, 1993. The Gross Domestic Product, GDP, is by definition

$$GDP = Consumption + Investment + Export - Imports \tag{117}$$

By algebra

$$Exports - Imports = GDP - Consumption - Investment \tag{118}$$

The definition for capital flows equation (7) in Appendix is

$$Capital\ Flows = -(Exports - Imports) + \Delta R \tag{119}$$

where ΔR is the variation of the central bank's reserves.

The Errors and Omissions Account data in the Balance of Payments are arbitrarily allocated to the capital flows as the trade account is usually more accurate than the capital flow data collected by monetary authorities. As I do not distinguish variation of reserves ΔR from the capital flows, the modeled expression for capital flows equation (119) is

$$Capital\ Flows = -Trade\ Account \tag{120}$$

The Balance of Payments Accounts

It follows from constant returns of scale technologies and profit maximization that the value of aggregate outputs Y_f and Y_i equal the value of aggregate input factors respectively:

$$\begin{aligned} Y_f &= wL + r^k K_y + Y_i^d \qquad (121) \\ Y_i &= r^k K_i + \pi^h(r^k)\ \mathcal{B}H \qquad (122) \end{aligned}$$

where w is wage per worker, r^k is return to domestic capital, $\pi^h(r^k)$ return to a unit of specific-endowment H and p price of tradable goods is normalized to one.

Summing both previous output equations, where the total domestic physical capital is $K_d = K_y + K_i$, results:

$$Y_f + (Y_i - Y_i^d) = wL + r^k K_d + \pi^h(r^k)\ \mathcal{B}H \qquad (123)$$

The left-hand side of equation (123), $Y_i - Y_i^d$ is the trade of intermediate goods, by definition:

$$Y_i^{trade} = Y_i - Y_i^d \qquad (124)$$

where Y_i^{trade} is the intermediate good output that is not consumed by the final good technology and that is exported (or imported) to (from) the foreign country.

As the right-hand side of equation (123) is by definition the GDP, then

$$Y_f + (Y_i - Y_i^d) = GDP. \qquad (125)$$

Two accounting identities are required to get the Balance of Payments. The GNI is as households choose to consume part of their income and save the rest,

$$GNI = G_n + Q \tag{126}$$

By definition of GNI, in terms of GDP,

$$GNI = GDP + r^f A^f \tag{127}$$

plugging equation (126) into (127)

$$GDP = G_n + Q - r^f A^f \tag{128}$$

which $r^f A^f$ is the payment service for holding foreign capital assets.

Plugging GDP equation (128) into equation (125),

$$Y_f + (Y_i - Y_i^d) = G_n + Q - r^f A^f \tag{129}$$

Plugging national saving $G_n = \dot{K}_d + \delta K_d + \dot{A}^f$ into the right-hand side of equation (129), and by algebra the Balance of Payments for the model is

$$Y_f - Q - \dot{K}_d - \delta K_d + (Y_i - Y_i^d) = \dot{A}^f - r^f A^f \tag{130}$$

I decompose the previous equation (130) into three items:

the trade of intermediate goods, which is in the left-hand side;

$$Trade\ of\ Intermediate\ goods = Y_i - Y_i^d \tag{131}$$

the trade of final goods, which is in the left-hand side;

$$Trade\ of\ Final\ Goods = Y_f - Q - \dot{K}_d - \delta K_d \tag{132}$$

and the capital flows, which is in the right-hand side;

$$Capital\ Flows = -\dot{A}^f + r^f A^f \tag{133}$$

In summary, the Balance of Payments for the models of this study is the set of the equations (131), (132) and (133):

$$Trade of Final Goods + Trade of Intermediate Goods = -Capital Flows \tag{134}$$

3.4 Model Equilibrium

3.4.1 Introduction

To simplify the solution of the firms' problems, the Roe et al.(2009) methodology, which is based on the dual approach theory to the producers' problems, allows writing of the equations in a simpler form. The characterization of the model equilibrium is set up in two parts, an intra-temporal equilibrium, and an inter-temporal equilibrium as follows.

All variables are normalized by dividing each variable by $\Omega(t)L(t)$, to avoid autonomous equations and help solve the solution. The system of equations is numerically solved in units of per effective worker, except wage w that is divided by $\Omega(t)$, which is called effective wage rate.

The analytical and numerical solution of the models as well as to estimate the steady state values of the variables are solved in per effective worker units. A hat symbol over the variables denotes per effective worker units. To simplify, I do not use the time notation unless there is ambiguity.

3.4.2 Solow Model Equilibrium Characterization

Given initial endowments $\{K(0), L(0), H\}$ and positive constant tradable goods price p, constant saving rate $\bar{g}_n$, and constant rate of return for the foreign asset r^f, a competitive equilibrium for this economy is a sequence of positive capital stock level $\{\hat{k}_t\}_{t\epsilon[0,\infty)}$, households consumption plan $\{\hat{q}_t\}_{t\epsilon[0,\infty)}$, and foreing asset stock $\{a_t^f\}_{t\epsilon[0,\infty)}$, factor rental prices $\{\hat{w}_t, r_t^d, \hat{\pi}_t^h\}_{t\epsilon[0,\infty)}$ for labor, capital and specific-endowment H, and production plans

$$\{\hat{y}_{y,t}, \hat{k}_{y,t}, \hat{y}_{i,t}, \hat{k}_{i,t}\}_{t\epsilon[0,\infty)}$$

such that at each instant of time t, households consume a fixed proportion of their contemporaneous income, firms maximize profits subject to their technologies at each instant of time t, and markets clear for all inputs and outputs. In addition, the no-arbitration between the values of capital and specific-endowment H, and the terminal no-Ponzi scheme condition are satisfied.

The Solow competitive equilibrium involves 14 endogenous variables and specifies 14 equations to pin them down. The market for final output clears by Walras' Law, $Q + S = Y$ is redundant.

Firms and households are assumed to expect the labor force, the labor technology and the specific-endowment to be following the paths:

- The labor force path, with exogenous growth rate n, is

$$L(t) = L(0)e^{nt} \tag{135}$$

- The Harrod labor-augmenting technology progress path, with exogenous growth index rate x, is

$$\Omega(t) = \Omega(0)e^{xt} \tag{136}$$

- The fixed, specific-endowment H productivity path, with exogenous growth rate γ,

$$\mathcal{B}(t) = e^{\gamma t} \tag{137}$$

- the initial conditions $L(0), \Omega(0) >> 0$ are set to 1.

Modeled Variable Estimations

The model estimates the following equations, after the equilibrium is solved

The gross final good output $\hat{y}_f$

$$\hat{y}_f = \hat{w} + r^k \hat{k}_y + \hat{y}_i^d \tag{138}$$

the $g\hat{d}p$:

$$g\hat{d}p = \hat{w} + r^k \hat{k}_d + \hat{\pi}^h(r^k)\ H \tag{139}$$

the $g\hat{n}i$ and $g\hat{d}p$ relationship,

$$g\hat{n}i = g\hat{d}p + r^f \hat{a}^f \tag{140}$$

and the modeled Balance of Payments:

$$Capital\ \hat{F}lows = -(Ex\hat{p}orts - Im\hat{p}orts) \tag{141}$$

3.4.3 Ramsey Model Equilibrium Characterization

The Ramsey model endogenizes saving, replacing the Solow consumption equation (65) in per effective worker based on a constant saving rate rule by the inter-temporal maximization of the social's felicity function that allocates current and future consumption, equation (103) in per effective worker.

Given initial endowments $\{K(0), L(0), H\}$ and constant tradable goods prices p, and constant rate of return for the foreign asset r^f, a competitive equilibrium for this economy is a sequence of positive capital stock level $\{\hat{k}_t\}_{t\epsilon[0,\infty)}$, households consumption plan $\{\hat{q}_t\}_{t\epsilon[0,\infty)}$, and foreing asset stock $\{a_t^f\}_{t\epsilon[0,\infty)}$, factor rental prices $\{\hat{w}_t, r_t^d, \hat{\pi}_t^h\}_{t\epsilon[0,\infty)}$ for labor, capital and specific-endowment H, and production plans

$$\{\hat{y}_{y,t}, \hat{k}_{y,t}, \hat{y}_{i,t}, \hat{k}_{i,t}\}_{t\epsilon[0,\infty)}$$

such that at each instant of time t,households solve the utility maximization problem, Euler Equation (103), firms maximize profits subject to their technologies, at each instant of time t, and markets clear for all inputs and outputs. In addition, the no-arbitration between the values of capital and specific-endowment H, and the terminal no-Ponzi scheme condition are satisfied.

The Ramsey competitive equilibrium involves 17 endogenous variables and specifies 17 equations to pin them down. The market for final output clears by Walras' Law, $Q + S = Y$ which is redundant.

3.5 Roe's Characterization of Equilibrium

Roe et al. (2009) modelling methodology for the Ramsey competitive equlibrium splits the model equilibrium defined in section 3.4 Chapter 3 into two parts, an intra-temporal and an intra-temporal equilibriums.

The intra-temporal equilibrium solves a system of static to make the model, and its solution, simpler and more tractable.

The inter-temporal equilibrium solves the inter-temporal budget income constraint differential equation, the rental rate differential equation of physical capital including the Euler consumption differential equation for the Ramsey model. The Euler equation replaces the Solow's rule on constant, exogenous saving rate.

3.5.1 The Intra-temporal Equilibrium

The Solow and the Ramsey models share the intra-temporal equilibrium, which is defined as follows. Following HOS, it is convenient to solve the supply side of the models in terms of the dual to the producers' problem.[24]

Given the endogenous pair $\{\hat{k}_t, \hat{q}_t\}_{t\epsilon[0,\infty)}$, of total per effective worker households' investment portfolio $\hat{k}_t$, and consumption $\hat{q}_t$, the intra-temporal equilibrium is characterized by the three-tuple sequence of positive values $\{\hat{w}_t, r_t^k, \hat{y}_{f,t}\}_{t\epsilon[0,\infty)}$ effective wage rate, rate of return of capital, and the per effective worker final good production, must satisfy the following four intra-temporal conditions at each instant of time:

1) Zero profit

a) Gross final good production from equation (29)

$$C\left(\hat{w}_t, r_t^k, p\right) - p = 0 \tag{142}$$

where $C(\hat{w}_t, r_t^k, p)$ is the production cost function per unit

[24] See Ph.D. dissertation by Irz, Xavier (2000)

of final goods. Price p is normalized to 1.[25]

b) Intermediate goods are implied by $\hat{\pi}^h(r_t^k)\ H$

2) Market clearance

a) Capital market

which, using the Shephard's and Hotelling's lemmas,

$\hat{k}_{y,t} + \hat{k}_{i,t} = \hat{k}_{d,t}$ can be written[26]

$$C_{r^k}\left(\hat{w}_t, r_t^k, 1\right).\hat{y}_{f,t} - \hat{\pi}_{r^k}^h\left(r_t^k, 1\right) H = \hat{k}_{d,t} \tag{143}$$

where $C_{r^k}(\hat{w}_t, r_t^k, 1)$ per unit of output $\hat{y}_{f,t}$

is the partial derivative of $C(\hat{w}_t, r_t^k, 1)$

respect to r_t^k; $\hat{\pi}_{r^k}^h(r_t^k, 1)$ per unit of H is

the partial derivative of $\hat{\pi}^h(r_t^k, 1)$ respect to r_t^k

is per effective worker capital for intermediate

good technology $\hat{k}_{i,t}$

b) Labor market

$$C_{\hat{w}}\left(\hat{w}_t, r_t^k, 1\right).y_{f,t} = 1 \tag{144}$$

where $C_{\hat{w}}(\hat{w}_t, r_t^k)$ is the derivative respect to $\hat{w}_t$ of the

$C(\hat{w}_t, r_t^k)$ function. $L(0)$ is normalized to 1.

c) Commodities

---

[25] The function $C(.)$ is the cost function, the $C_w(.)$ and $C_{r^k}(.)$ the derivates of $C(.)$ respect to w, and r^k respectively. I reserve the use of the letters with subscripts C_i and C_y for intermediate goods production and intermediate goods consumed by the final goods technology respectively. Roe et al. (2010)

[26] This equation will generate, in addition to the capital clearance equation, a differential equation of r^k to be included in the model equilibrium.

The intermediate good trade is

$$\hat{y}_{i,t}^{trade} = \hat{y}_{i,t} - \hat{y}_{i,t}^{d} = \hat{\pi}_{i,p}^{h}(r_t^k, p)BH - \hat{y}_p^f(\hat{w}_t, r_t^k, p)\hat{y}_{f,t} \tag{145}$$

where the $\hat{\pi}_{i,p}^{h}(.)$ and $\hat{y}_p^f(.)$ functions are the derivatives of $\hat{\pi}_i^h(.)$ and $\hat{y}_f(.)$ respect to price p, respectively.

The Reduced Forms for the Intra-Temporal Equilibrium

The characterization equations (143) and (144) are easily expressed in relevant reduced forms as a system of two static equations, (146) and (148), which are two unknowns: $\hat{w}_t$ and $\hat{y}_{f,t}$ as a function of r^k. After solving the static two-equation system,

1) From the zero profit condition, effective wage is

$$\hat{w}_t = w\left(r_t^k\right) \tag{146}$$

2) The effective per effective worker final output is

$$\hat{y}_{f,t} = y_f\left(r_t^k\right) \tag{147}$$

3) the equation (147) is deduced by plugging r^k in the labor market clearing (144),

$$C_{\hat{w}}\left(r_t^k\right).\hat{y}_{f,t} = 1. \tag{148}$$

The next step is the inter-temporal equilibrium that solves the rate of return r_t^k.

3.5.2 The Inter-temporal Equilibrium

Households' income budget constraint

The physical capital is obtained by replacing the relevant reduced forms for $\hat{w}$ and $\hat{y}_f$ equations (146) and (148) into the households' income budget constraint equation (27), which is expressed in per effective worker terms. The result is the equation of motion of total assets k as a function of the foreign asset $\hat{a}_t^f$, of the endogenous rate of return r^k, of the households' consumption $\hat{q}$, and of the exogenous foreign rate of return r^f, for every time t. Thus,

$$\dot{\hat{k}} = \hat{w}(r^k) + \hat{k}\ (r^k - \delta - n) + \hat{a}_t^f\ [r^f - r^k + \delta] + \hat{\pi}^h(r^k)\ \mathcal{B}H - \hat{q} \tag{149}$$

Households own the foreign asset, denoted as $\hat{a}_t^f$ in per effective worker units, is assumed as a proportion of the total households' wealth for every time t

$$\hat{a}^f \equiv \tau\ \hat{k} \tag{150}$$

where τ_t is the exogenous country risk shock, $\hat{k}_t$, is the households' investment wealth portfolio, which is composed of the total domestic capital and foreign assets.

Plugging equation (150) into equation (149), the income budget constraint in terms of total wealth $\hat{k}_t$ is

$$\dot{\hat{k}} = \hat{w}(r^k) + \hat{k}\ (r^k - \delta - n) + \tau\ \hat{k}_t\ [r^f - r^k + \delta] + \hat{\pi}^h(r^k)\ \mathcal{B}H - \hat{q} \tag{151}$$

Equation of motion for rental rate of mobile capital

The domestic rate of return differential equation as a function of per effective worker domestic assets k_d is deduced from the market-clearing condition of capital,

$$\hat{k}_y + \hat{k}_i = \hat{k}_d \tag{152}$$

Plugging the equations $C_{r^k}(.) = \hat{k}_y$; $\hat{\pi}^h_{r^k}(.) = \hat{k}_i$ and $\hat{w} = w(r^k)$

respectively into the left-hand side of equation (152) hence

$$C_{r^k}[\hat{w}(r^k), r^k]\ \hat{y}_f - \hat{\pi}^h_{r^k}(r^k)\ \mathcal{B}H = \hat{k}_d \tag{153}$$

By algebra it equals zero

$$C_{r^k}[\hat{w}(r^k), r^k]\ \hat{y}_f - \hat{\pi}^h_{r^k}(r^k)\ \mathcal{B}H - \hat{k}_d = 0 \tag{154}$$

Solve this equation for $\hat{y}_f$ and note that it is separable in $\hat{k}_d$

$$\hat{y}_f = Y^f(r^k, 1, \hat{k}_d) = \frac{\hat{k}_d + \hat{\pi}^h_{r^k}(r^k)\ \mathcal{B}H}{C_{r^k}[\hat{w}(r^k), r^k]} \tag{155}$$

Substitute equation (155) into the labor market clearing

condition (144) to obtain

$$C_w[\hat{w}(r^k), r^k].Y^f(r^k, \hat{k}_d) = 1 \tag{156}$$

In order to develop the differential motion equation for r^k, I define the domestic physical capital market clearing equation (154) as the function $f(r^k, \hat{k}_d)$ which equals zero

$$f(r^k, \hat{k}_d) \equiv C_w[\hat{w}(r^k), r^k].Y^f(r^k, \hat{k}_d) - \hat{\pi}^h_{r^k}(r^k)\ \mathcal{B}H - \dot{\hat{k}}^d = 0 \tag{157}$$

plugging $\hat{k}_d = (1-\tau)\hat{k}$ into equation (157) which is expressed in households' investment portfolio k_t

$$f(r^k, \hat{k}) \equiv C_w[\hat{w}(r^k), r^k].Y^f(r^k, \hat{k}) - \hat{\pi}^h_{r^k}(r^k)\ \mathcal{B}H - \dot{\hat{k}}(1-\tau) = 0 \tag{158}$$

Note that equation (158) is linear in k and r^k, so totally differentiate the equation with respect to time, which equals zero:

$$f_{r^k}(r^k, k)\ \dot{r}^k + f_k(r^k, k)\ \dot{\hat{k}} = 0 \tag{159}$$

and solve for $\dot{r}^k$, which yields

$$\dot{r}^k = -\frac{f_{k_d}(r^k, \hat{k})}{f_{r^k}(r^k, \hat{k})}\ \dot{\hat{k}} \tag{160}$$

To get the equation of motion of the rate of return r^k, plug in $\dot{\hat{k}}$ from the households' income budget constraint (150) into the equation (160), it can be expressed

$$\dot{r}^k = R(r^k, \hat{k}, \hat{q}) \tag{161}$$

Inter-temporal Solow and Ramsey Equilibriums

For the Ramsey model, the intra-temporal equilibrium is composed of a system of three differential equations of motion: equation (103), equation (151) and equation (161) that are solved for three unknowns, the $\hat{q}_t, \hat{k}_t$, and r^k_t composed by

- the Euler equation (103) that expresses the consumption path per effective worker $\dot{\hat{q}}$

$$\frac{\dot{\hat{q}}_t}{\hat{q}_t} = \frac{1}{\mu}[(r^d_t - \rho - \mu\ x) + (r^f - r^d_t)\ \tau_t]$$

- the households' income budget constraint in per effective worker $\dot{\hat{k}}$ equation (151),

$$\dot{\hat{k}} = \hat{w}(r^k) + \hat{k}\ (r^k - \delta - n) + \tau\ \hat{k}_t\ [r^f - r^k + \delta] + \hat{\pi}^h(r^k)\ \mathcal{B}H - \hat{q}$$

- and the rate of return of domestic capital $\dot{r}^k$ equation (161)

$$\dot{r}^k = R(r^k, \hat{k}, \hat{q})$$

Where the initial consumption level $\hat{q}(0)$ is endogenous for the Ramsey model.

The non-Ponzi scheme and transversality condition for the Hamiltonian are satisfied.

For the Solow model as the saving rate $\bar{g}_n$ is constant, the consumption rule is $\hat{q} = (1 - g_n)\ \hat{gnp}$ (equation(64)), the inter-temporal equilibrium is composed of the system of two differential equations for two unknows, the $\hat{k}_t$, and r^k_t :

- income constraint equation (151) in $\dot{\hat{k}}$,

$$\dot{\hat{k}} = \hat{w}(r^k) + \hat{k}\ (r^k - \delta - n) + \tau\ \hat{k}_t\ [r^f - r^k + \delta] + \hat{\pi}^h(r^k)\ \mathcal{B}H - \hat{q}$$

- and the differential equation (161) for $\dot{r}^k$.

$$\dot{r}^k = R(r^k, \hat{k}, \hat{q})$$

3.6 International Transactions

The Balance of Payments accounts per effective worker for the Solow and the Ramsey models are as follows:

The trade account is

$$C_p\left(\hat{w}, r^k, p\right).\hat{y}_f - \hat{\pi}_p^h\left(r^k, p\right).\mathcal{B}H > 0\ \ (import) < 0\ \ (export) \tag{162}$$

and the equation of motion of foreign assets is

$$c\hat{f} = \dot{\hat{a}}^f + \hat{a}^f(r^{,f} - x - n) \tag{163}$$

The trade of final goods is

$$Trade\ of\ Final\ goods = \hat{y}_f - \hat{q} - \dot{\hat{k}}^d - \hat{k}^d\ \ (x+n) \tag{164}$$

and the trade of intermediate good is

$$Trade\ of\ Intermediate\ goods = \hat{y}_i - \hat{y}_i^d \tag{165}$$

4 Calibration and Validation of Models

4.1 Calibration

The models have nine parameters that need to calibrate to delivery quantitative results: Three production parameters and six behavioral and technical. Kydland et al (2001) suggested "(T)he ultimate purpose of the calibration procedure is to produce reliable numbers for the parameters that link long-run with short-run variables in the decision rules that guide the actions of households and firms. This will guarantee the decision rules provide a reliable device with which to measure, for example, the strength of the recovery that should follow a recession of a given intensity."

I calibrate the Solow and the Ramsey models to data, so the balance-growth path replicates the actual economy on the dimensions associated with the long-term growth. Cooley and Prescott (1995)

I choose two periods, a capital flow stable period 1940-1951 and a capital flow greater volatility period 1993-2004 rather than the entire period that is available 1900-2004 because those periods include the empirical regularities the data shows for stable and volatile capital flow regimes.

For the period 1993-2004, I took the initial values for the year 1993 from the Global Trade Analysis Project (GTAP) database of the Argentinean economy for the 1993 year. For the period 1940-1951, I selected the macrovariables of the 1940 year as initial values from Ferreres (2004).

The gross final good production is equation (23)

$$Y_f(t) = M\ [K_y(t)^{\alpha}\ (\Omega(t)L(t))^{1-\alpha}]^{1-\sigma} Y_i^d(t)^{\sigma} \tag{166}$$

The parameters α and σ for the production functions equation (23) are calculated

Table 16: Production Technology Parameters

Capital Share of final-good output	Intermediate-good input elasticity	Capital share of intermediate-good output
α	σ	β
0.217	0.246	0.53

based on data from the GTAP. I use a la Jones production technology with intermediate good inputs, where the capital share of Y_f is $\alpha = 0.217$. The intermediate good input elasticity results $\sigma = 0.246$, from the relation between the intermediate goods used Y_i^d and Y_f, which is obtained from the GTAP input-output matrix. However, Charles Jones (2011) calculates a higher value $\sigma = 0.38$ for the Argentinean economy. M is calculated from data in equation (166) for the initial condition $t = 0$.

The intermediate good production, equation (24)

$$Y_i(t) = N \; K_i(t)^{\beta} \; [\mathcal{B}\,(t) \; H]^{1-\beta} \tag{167}$$

For the purpose of this study, I excluded labor from the capital-intensive intermediate technology to make the model simpler and more tractable.[27] I estimated β the capital share of the intermediate good technology from the input-output GMAT matrixes that results $\beta = 0.53$. N is calculated from data in equation (167) for the initial condition $t = 0$.

The annual growth rate of working-age population $n = 1.9\%$ is taken from the Encuesta Permanente de Hogares, Instituto de Estadistica y Censos (INDEC), Ministerio de Economia, Argentina (2004)

The Harrod labor-augmenting technological progress is estimated at $x = 0.9\%$

[27] Hayami and Ruttan, 1991, Table 6-4, p. 149. This table reports the results of eight different studies for intercountry agricultural production functions.

from an average of $TFP_t = (1-\alpha)\ x_t$, equation (12). See TFP analysis on Chapter 1.

For the Ramsey model, the maximization of the social felicity function is equation (80)

$$\underset{(q_t)}{max} \int_0^{+\infty} \frac{[(q_t)^{1-\mu} - 1]}{(1-\mu)}\ L(0)\ e^{-(\rho-n)t}\ dt \tag{168}$$

The discount factor is chosen $\rho = 0.06$ so to ensure a 3.0% steady-state rental rate r^d (net of depreciation 4.0%) corresponding to the annual real rate in Argentina.

Ahumada et al (2004) describe the volatility of the factor discount ρ and the smoothing parameter μ of the Euler equation (103) for the Argentinean economy in the 1990s. They statistically reject that both parameters are constant values as the volatility of the smoothing parameter μ is greater than 2 standard deviations-to-media ratio that suggests that Argentinean households do not or cannot smooth consumption during the 1990s.[28]

I show this feature of the Ramsey model for the period 1993-2004, which the Euler equation specified with country risk shocks does not fit consumption. All other empirical regularities other than consumption and GNI in the volatile period 1993-2004 are well fitted by the Solow and the Ramsey models for both periods under study, 1940-1951, and 1993-2004.

The inverse of the elasticity of inter-temporal substitution μ is assumed 0.7 according to standard values by Ahumada et al (2004).

The growth rate of the specific-endowment H, which includes land, infrastructure, institutions and ports, is set to $\gamma = 0$ as there is no evidence in the Argentinean data that there has been improvement, growth or deterioration in each of the components

[28] Ahumada et al (2003) "An estimation of the Deep Parameters describing the Consumer Behavior of Argentina"

Table 17: Behavioral and Technological Parameters of the Models

Discount factor felicity function	Inverse of the elasticity of Inter-temporal substitution	Growth rate of labor force	Harrod rate of labor augmenting technological progress	Growth rate of the specific-resource H	Depreciation rate
ρ	μ	n	x	γ	δ
0.06	0.70	0.019	0.009	0	0.04

of H for the two modeled periods. [29]The level of the components of H measured by the capital stock series Maia (2004) and land, infrastructure and ports capital remained constant, except for institutions as there are no data.

H and the initial value of labor force $L(0)$ are normalized to 1 to simplify calculations.

The depreciation rate comes from the physical capital stock series developed by Maia (2001) that used a typical value $\delta = 4.0\%$.

The following table summarizes the calibration parameters.

I use the calibrated Ramsey and Solow models to simulate the economic recovery to country risk shocks and their effects on the small open economy. A cost and benefit analysis measures the impact on output.

4.2 Analytical and Numerical Solution

The competitive equilibrium involves for Solow model four endogenous variables and specifies four equations to pin them down. For the Ramsey model, five endogenous variables and specifies five equations to pin them down. The market for final output clears by Walras' Law, which is redundant. It consists of three (inter-temporal) differential equations, and two static (intra-temporal) equations.

The Solow model solution is made up of two dynamic differential equations in $\dot{k}_t$

[29]Ruttan (1998) reports the results of a study in the US suggesting that if the 1992 erosion rates continued 100 years, the yield loss at the end of the period would amount to only 2 to 3%. He concludes that soil erosion, while potentially important problem at a local level, does not seem substantial when considered on a larger scale. Consequently, γ is set to zero.

equation (149) and $\dot{r}_t^k$ equation (161) is numerical solved by Wolfram Mathematica algorithms.

The Ramsey analytical solution is composed of the inter-temporal equilibrium and the intra-temporal equilibrium. For the Ramsey inter-temporal equilibrium paths, Wolfram Mathematica algorithms solve the endogenous dynamic tuple $\left\{\hat{k}\left(t\right), r^k(t), \hat{q}(t)\right\}_{t\epsilon[0,\infty)}$, from equations (149), (161) and (103). The system of ordinary differential equations is non-autonomous as $\gamma = 0$, and they explicitly depend on time t.

The intra-temporal equilibrium conditions have been reduced to a system of two static equations $\{\hat{w}(r_t^k),\ \hat{y}_f(r_t^k)\ \}_{t\epsilon[0,\infty)}$, that are in function of domestic capital rate of return r_t^k holding at each time t. The system is then solved using the Roe et al.(2009) methodology that uses dual properties of production maximization and cost minimization.

Then, for the Solow and Ramsey models, the intra-temporal pair

$\left\{\hat{w}(r_t^k),\ \hat{y}_f(r_t^k)\right\}_{t\epsilon[0,\infty)}$ is solved by plugging the endogenous variable, $\{r_t^k\}_{t\epsilon[0,\infty)}$ from the inter-temporal equilibrium into them. The result is the tuple

$\{\hat{w}(t),\ \hat{y}_f(t)\}_{t\epsilon[0,\infty)}$ for every time t.

The Ramsey model equilibrium requires the non-Ponzi scheme that is expressed as $\rho > n$, and which is satisfied by the parameter values of the Argentinean economy. The Hamilton operator that solves the Ramsey household maximization requires the transversality condition $r^d(t) > n + x$ for every time, which is also satisfied.

Finally, the Balance-of-Payments accounts are estimated according to the above four equations, (162), (163), (164) and (165).

4.3 Incomplete Financial Markets and Steady-State Values

The Solow and Ramsey models show incomplete asset markets as modeled households have only access to a single asset, rather than having access to a complete array of claims.[30]

The absence of assets to complete the array of claims is the only single source of market imperfection that may affect the stationarity of the modeled variables, the convergence to steady state and the steady state values. Furthermore, the model equilibrium is not Pareto-efficient and consequently there are welfare losses.

For this study, the asset market incompleteness does not generate non-stationary time series as the hypothesis of non-stationarity is rejected for both modeled and actual time series, according to standard and augmented Dickey Fuller tests. Even though Roe et al (2009) methodology does not explicitly accommodate stochastic events, the methodology and the economy's parameters do not generate non-stationary series in the Solow and the Ramsey models, which are free of random walks for the study.

Although the focus of the study is to assess model abilities to match data for the short-term macroeconomic fluctuations, analysis of the per worker steady-state values is included to evaluate the economic recovery after country risk shocks and the associated capital flows' effects. A simulation with large, transient shocks will show how the imperfection affects the convergence to the steady state.

Using the stationary property, short-run τ shocks at the start of the model lifetime do not make the model variables wander around the steady states. The short-run τ shocks have no long-run effects on the steady-state values of the economy.

Then, the numerical solution of the Ramsey model that includes local approxima-

[30] Under complete financial markets, agents can insure themselves against all risks with a complete set of state contingent securities.

tion techniques around the steady-state positions is, therefore, valid. The approximation algorithm is used to compute the initial value of the consumption per effective worker (which is endogenous for the Ramsey model) given the consumption steady state value.

The short-run periods 1940-1951 and 1993-2004 under study, which are within the range $0 < t < 12$, include country shocks τ_t and positive constant $r^f > 0$ as it is described in the model set up in Chapter 3. To simplify, the country risk τ_t and the rate of return of the foreign asset r^f are assumed to be zero from the 13th year until the steady state. Therefore, the foreign rate of return $r^f = 0$ cancels payments and returns for holding remaining (non-zero) foreign assets A^f after $t > 12$ until the steady state. This guarantees that steady-state values for both models are unique and do not depend on the initial values of foreign asset stock A^f, of the exogenous foreign rate of return r^f, and of the country risk τ_t.

The market imperfection does not significantly affect the Ramsey consumption smoothing. There are two periods where there is a small deviation to the complete market Euler equation as per differential in returns r^d and r^f. See the section Transmission Mechanism of Country Risk shocks on consumption and the endogenous function $r^f - r^d_t$ equation of the Euler equation(103).

The Euler equation requires funding to transfer wealth between current and future consumption. That is households choose between current and future consumption (an inter-temporal choice) on a smooth basis. The Solow model is not affected as modeled consumption is a fixed proportion of contemporaneous income, an intra-temporal choice.

The study of steady states also allows estimating the long-run multiplier effects of using intermediate goods as input in the final good production on output and output productivity, see equation (177).

4.4 Validation of Models

Solow and Ramsey model time series are compared to data in two periods of the Argentinean economy, a stable period 1940-1951 with capital flow volatility of 1.1% and a volatile period 1993-2004 with volatility of 4.8%, which is four times greater than the stable one.

The saving-GNI rate for the stable period is 17.8% with a 1.5% standard deviation, and for the volatile period 19.1% with 4.4% standard deviation, which is three times larger than the stable period. The GDP-Capital flows relationship is counter-cyclic for the stable period and pro-cyclic for the volatile period as is shown in the empirical study, in Chapter 2.

The fitting comparison is measured by the contemporaneous correlation coefficients between the modeled and the actual time series, shown in Table 18. For the Solow Model in period 1940-1951, Figure 15 in Appendix shows the actual and modeled households' consumption, Figure 16 actual and modeled GDP, Figure 17 actual and modeled Capital stock and Figure 18 actual and modeled trade. Following Figures from 19 to 25 in Appendix show for the Solow model period 1993-2004 and Ramsey modeled for the stable and volatile periods.

The Solow model fits the data for the stable and volatile periods for the four empirical regularities. Every time there is a trade reversal the Solow model replicates it.

The Ramsey model fits data for both periods except for two macrovariables. First, the Ramsey model does not replicate actual consumption in the volatile period 1993-2004; however, it fits consumption in the stable period 1940-1951. Second, because consumption is not fitted, the Ramsey model does not replicates GNI for the volatile period. However, it does replicate consumption and GNI for the stable period.

Table 18: Validation of Models

Data	Stable Period 1940-1951		Volatile Period 1993-2004	
Capital Flows/GNI Volatility [1]	**1.1%**		**4.8%**	
National Saving/GNI [2]	**17.8% (1.5%)**		**19.1% (4.4%)**	
Consumption/GNI [2]	**82.2% (1.5%)**		**80.9% (4.4%)**	
Capital Flows - GDP Relationship [4]	**Counter-cycle**		**Pro-cycle**	
Contemporaneous Correlation [3] Modeled Time Series and data	**Solow Model**	**Ramsey Model**	**Solow Model**	**Ramsey Model**
Consumption	0.99	0.96	0.81	**0.18**
GNI	0.99	0.91	0.87	**0.12**
Physical Capital Stock	0.73	0.91	0.86	0.85
Trade	1.00	0.84	0.95	0.96
Contemporaneous Correlation [3] between Modeled Time Series				
Capital Flows - GDP Relationship	-0.93		0.70	
	Counter-cycle		**Pro-cycle**	

1 Standard Deviation
2 Average and (Standard Deviation)
3 Pearson linear correlation
4 Based on Contemporaneous correlation. See Table 7, Chapter 2 Empirical Background

For the first discrepancy, consumption data for the period 1993-2004 show that when real households face a capital flows reversal they appear not smooth consumption over the period. The weaker correlation coefficient between the Ramsey consumption path and the actual consumption for the volatile period 1993-2004 is 0.16.

The Ramsey modeled consumption is impacted in the volatile period 1993-2004, by the progressive reduction of capital inflows started in year 1998 and ended in 2001 with a sudden stop of capital inflows.

To analyze the impact, the period 1993-2004 is split in two periods, a capital inflow period from 1993 to 1998, and a capital outflow period from 1999 to 2002, in where the correlation coefficients between consumption and capital flows are 0.92 and -0.89 respectively. The negative correlation shows the discrepancy when a capital flow reversal occurs and the lack of change in the consumption trend. The Euler equation is rigid to catch the downward trend change of the sudden stop of the large

Table 19: Capital Flow Behavior - 1993-2004

Year Period	Capital Flow behavior	Correlation Coefficient
1993-2000	Capital Inflows	0.96
2000-2002	Sudden Stop of Capital Inflows	-0.98
2002-2004	Capital Inflows resumed	0.99

capital inflow, which is 11% of the GDP. The Euler equation, which models the Ramsey inter-temporal consumption choice, requires the financial markets should be perfect. Conversely, the Solow's saving rate rule that makes the consumption a fixed proportion of households' contemporaneous income does not require perfect financial markets as there is no inter-temporal consumption choice.

See Appendix, Figure 31 where Ramsey model consumption is compared with Solow model consumption. It shows that when capital inflows begin to decline in year 1998, consumption in the Solow model lessens, but the Ramsey model consumption continues to grow as the Euler equation cannot follow the trend downwards. In year 2001, there is a large, sudden stop of capital inflows, the Solow model consumption lessens, and the Ramsey model consumption continues to grow up until year 2002 out of the country risk shock. After year 2002, when the 2001 country risk shock vanishes, both modeled consumption paths grow upwards.

Kydland et al (1997) mentioned the lack of perfect financial markets in the Argentinean economy for the 1990s: "In an economy incapable of transferring wealth between periods, economic agents will use up all they produce in every period - that is consumption will be exactly equal to income period after period. Although there is no (financial) credit in these economies, the volatility of consumption cannot exceed that of output (or income)". In periods of greater capital volatility, when capital flows reverse, it seems there is no actual funding available to finance the consumption gap between the real households' consumption and the modeled consumption growth path.

Several capital outflows are shown in the stable period, which transmit effects on consumption, physical capital, GNI, and trade aggregate levels. However, in the stable period 1940-1946, capital flow volatility is lower and, therefore, liquidity constraints in the financial markets may not bind.[31]

[31] Liquidity constraints in small open economies is a new research topic, which may be addressed in the future.

Volatility of Euler Equation Parameters

The assumed constant parameters of the Euler equation, the inverse of elasticity and the discount factor are greater volatile in the real economy. Ahumada et al.(2004) show that the statistical GMM-Euler equation tests reject the discount factor ρ is constant for the volatile period 1990-2000. Volatility of the inverse of the elasticity of inter-temporal substitution factor is two standard deviations of the media that shows the use of the Euler equation, cannot replicate actual aggregate consumption per worker, even under Ahumada et al. (2004) specification.

Summary

The Solow model predicts data for the stable and volatile periods. The Ramsey model in stable periods fits well consumption, gross national income, capital stock and trade. In volatile periods, Ramsey replicates trade and capital stock, but it does not replicate consumption and GNI. See Figures 27, 28, 29 and 30 in the Appendix that show the modeled and data for each of the four empirical regularities.

Ramsey model fits slightly better than Solow in stable periods; conversely Solow model provides better fitting than Ramsey does in volatile periods and in greater saving rate volatility periods, 4.4% in the period 1993-2004 versus 1.5% in the stable period.

The models predict GDP and its growth rate as the modeled growth for the years 1993-2004 is 8.93% close to the 8.98% for data shown. Figure 21 in the Appendix shows how modeled GDP fits data for the period 1993-2004.

Solow and Ramsey models fit physical capital stock in both periods as there is a fall in physical capital when there are capital outflows, and an increase when there are capital inflows.

The modeled trade account shows a reversal as the data do: when there is a capital flow reversal, the trade account reverses at the same time.

I use the calibrated Solow and Ramsey models to simulate economies by changing, either the pattern of the τ shocks, or the parameters σ, or the saving rate $\bar{g}_n$ to show the macroeconomic impacts of every isolated change.

5 Discussion of Models' Results

5.1 Introduction

In this chapter, I use the calibrated Ramsey model for the period 1993-2004 and its generated times series of macrovariables to explain the empirical regularities that are related to capital flow volatility, which were described in Chapter 2.

5.1.1 On Investment in Physical Capital

Table 20 shows how the Ramsey model explains the behavior relationship between physical capital stock and the capital flows. When a capital outflow hits the economy, foreign asset stock A^f increases, domestic capital stock K^d declines, then GNI falls. See years 2001 and 2002.

Otherwise, when a capital inflow hits the economy, GNI decreases, K^d increases, and GNI rises. See years 1993 to 1998 and 2003 to 2004.

The physical capital stock series generated by the model closely predicts the actual stock adjusted by the capacity utilization rate. Data were sourced by Fundacion de Investigaciones Economicas Latinoamericana FIEL (2010).

5.1.2 On Marginal Product

Table 21 shows the rate of return r^k of capital stock and wage w. Rate of return declines every time a capital inflow hits the economy and capital stock rises in years 1995 to 1998. Afterwards until year 2002 the rate of return increases to 9.2%. Capital outflows during years 2000 and 2002 cut the rate of return. The foreign rate of return r^k is, by assumption, exogenous and constant over time.

Contrary to the rate of return pattern, wage increases in periods of capital inflows, and decreases in capital outflow periods.

Table 20: Explanation of Modeled Physical Capital Variations

	Domestic	Foreign	Total				Capital	ΔCapital	
Year	Kd	Af	Assets	ΔAssets	ΔKd	ΔAf	Flows	Flows	GNI
1993	1339463.3	-71397.8	1268065.5						147483.2
1994	1547887.9	-177217.5	1370670.4	102604.9	208424.6	-105819.7	1387.4	1387.4	154421.6
1995	1312323.7	-6076.0	1306247.7	-64422.7	-235564.2	171141.5	-1475.5	-2862.9	153339.7
1996	1478332.1	-90253.5	1388078.6	81830.9	166008.4	-84177.5	1082.3	2557.8	159771.7
1997	1823573.6	-281553.6	1542020.0	153941.4	345241.5	-191300.1	2306.7	1224.4	169041.0
1998	1961817.4	-335043.1	1626774.3	84754.3	138243.8	-53489.5	1023.9	-1282.7	174904.0
1999	1633717.8	-95267.0	1538450.8	-88323.5	-328099.6	239776.1	-2040.8	-3064.7	173482.1
2000	1488113.1	17718.1	1505831.2	-32619.6	-145604.7	112985.1	-899.4	1141.4	174264.3
2001	1191160.3	215753.7	1406914.0	-98917.2	-296952.8	198035.6	-1887.5	-988.1	170796.1
2002	712130.5	503181.1	1215311.6	-191602.4	-479029.8	287427.4	-3006.3	-1118.8	157872.2
2003	921864.8	375585.3	1297450.1	82138.5	209734.3	-127595.8	1126.9	4133.2	168643.8
2004	1184033.4	225184.2	1409217.6	111767.4	262168.6	-150401.2	1499.6	372.7	180019.4
	In thousands of 1993 local currency								

Table 21: Explanation of Modeled Marginal Product Variations

	Domestic					Capital	ΔCapital
Year	rk	Wage	Δrk	ΔW	Δrf	Flows	Flows*
1993	5.0%	97816.4					
1994	4.6%	101031.8	-0.4%	3215.4	0.0	1387.4	1387.4
1995	5.3%	98231.8	0.7%	-2800.0	0.0	-1475.5	-2862.9
1996	4.9%	100965.4	-0.3%	2733.6	0.0	1082.3	2557.8
1997	4.3%	105608.5	-0.6%	4643.1	0.0	2306.7	1224.4
1998	4.2%	107559.8	-0.1%	1951.3	0.0	1023.9	-1282.7
1999	4.8%	104241.6	0.7%	-3318.3	0.0	-2040.8	-3064.7
2000	5.3%	102778.5	0.4%	-1463.1	0.0	-899.4	1141.4
2001	6.3%	98762.6	1.0%	-4015.9	0.0	-1887.5	-988.1
2002	9.2%	89421.9	3.0%	-9340.6	0.0	-3006.3	-1118.8
2003	7.8%	94587.5	-1.4%	5165.5	0.0	1126.9	4133.2
2004	6.6%	99849.9	-1.2%	5262.5	0.0	1499.6	372.7
	In thousands of 1993 local currency						

Table 22: Explanation of Modeled GNI Variations - Demand Side

Year	Consumption	National Saving	GNI	ΔGNI	ΔConsumption	ΔNational Saving	Capital Flows	ΔCapital Flows	Consumption Growth
1993	102160.0	45323.2	147483.2				14.3		
1994	106966.2	47455.5	154421.6	6938.5	4806.2	2132.3	1387.4	1373.1	4.7%
1995	106216.7	47123.0	153339.7	-1081.9	-749.4	-332.5	-1475.5	-2862.9	-0.7%
1996	110672.1	49099.6	159771.7	6432.0	4455.4	1976.6	1082.3	2557.8	4.2%
1997	117092.9	51948.2	169041.0	9269.3	6420.7	2848.6	2306.7	1224.4	5.8%
1998	121154.0	53749.9	174904.0	5862.9	4061.2	1801.7	1023.9	-1282.7	3.5%
1999	120169.2	53313.0	173482.1	-1421.8	-984.9	-436.9	-2040.8	-3064.7	-0.8%
2000	120711.0	53553.4	174264.3	782.2	541.8	240.4	-899.4	1141.4	0.5%
2001	118308.6	52487.5	170796.1	-3468.2	-2402.4	-1065.8	-1887.5	-988.1	-2.0%
2002	109356.3	48515.9	157872.2	-12923.9	-8952.3	-3971.7	-3006.3	-1118.8	-7.6%
2003	116817.7	51826.1	168643.8	10771.6	7461.4	3310.2	1126.9	4133.2	6.8%
2004	124697.4	55321.9	180019.4	11375.6	7879.7	3495.8	1499.6	372.7	6.7%
	In thousands of 1993 local currency								

5.1.3 On the Consumption

The difference equation of GNI equation (53) is

$$\Delta GNI = \Delta National\ Saving + \Delta Consumption \tag{169}$$

where the Δ symbol denotes the variation of the variable respect to the previous year. See Table 22 for values.

Capital inflow from 1993 to 1998 and from 2003 to 2004 decrease domestic saving rate, increase aggregate consumption, and GNI. Capital outflow from 1999 to 2002 increase domestic saving rate, and reduce GNI.

Consumption annual growth and saving increases with positive changes of capital flows, and decreases with negative variations of capital flows over the entire period 1993-2004.

5.1.4 On Gross Domestic Product

Table 23 shows the variations of the GDP based on its difference equation

$$\Delta GDP = \Delta Y^f - \Delta Y^i + \Delta Y^{exp} \tag{170}$$

Table 23: Explanation of Modeled GDP Variations - Supply Side

Year	Yf	Yi	Yi,exp	GDP	ΔGDP	ΔYf	ΔYi	ΔYi,exp	Capital Flows	ΔCapital Flows	GDP Growth
1993	168650.5	41556.6	21817.2	148911.1							
1994	176995.7	43612.9	24583.2	157966.0	9054.8	8345.2	2056.3	2766.0	1387.4	1387.4	6.08%
1995	174857.9	43086.1	21689.4	153461.2	-4504.8	-2137.8	-526.8	-2893.8	-1475.5	-2862.9	-2.85%
1996	182614.2	44997.3	23959.9	161576.7	8115.5	7756.3	1911.2	2270.4	1082.3	2557.8	5.29%
1997	194083.8	47823.5	28411.6	174671.9	13095.2	11469.6	2826.2	4451.8	2306.7	1224.4	8.10%
1998	200848.9	49490.5	30246.2	181604.6	6932.7	6765.0	1666.9	1834.6	1023.9	-1282.7	3.97%
1999	197783.0	48735.0	26339.3	175387.3	-6217.3	-3065.9	-755.4	-3906.9	-2040.8	-3064.7	-3.42%
2000	198143.1	48823.8	24590.4	173909.7	-1477.6	360.1	88.7	-1748.9	-899.4	1141.4	-0.84%
2001	193463.0	47670.5	20688.3	166480.7	-7429.0	-4680.1	-1153.2	-3902.1	-1887.5	-988.1	-4.27%
2002	177982.8	43856.1	13681.3	147808.1	-18672.6	-15480.1	-3814.4	-7006.9	-3006.3	-1118.8	-11.22%
2003	191291.8	47135.6	16975.4	161131.6	13323.6	13309.0	3279.4	3294.0	1126.9	4133.2	9.01%
2004	205182.0	50558.2	20891.5	175515.3	14383.6	13890.2	3422.6	3916.1	1499.6	372.7	8.93%
	In thousands of 1993 local currency										

An increase in capital flows increases outputs Y^f and Y^i in years 1995 to 1997, mainly because K_d and wages rise more than the reduction of r^k. See also Table 21.

A decrease in capital flows decreases outputs Y^f and Y^i as K^d and wages decline while capital outflows positively impact on rate of return r^k.

Positive variations of capital flows induce positive variations of $Y^{i,exp}$. An increased change in capital flows increases $Y^{i,exp}$ as a decrease in capital outflows decreases $Y^{i,exp}$, and reduces GDP by 11.2% in year 2002. GDP grows as capital flows increase. It is a change in capital flows that is associated with a change in GDP over the entire period.

5.1.5 On Trade Reversals

Table 24 shows that capital inflows dominate the period 1993-1998 except in the year 1995 for the Mexican financial crisis, when there is a small capital outflow that is not large enough to lead to a trade reversal. Trade reduces to -\$121.6 in the same year mainly because of exports increases \$5789.8 and imports decline -\$2367.0. To understand the lack of trade reversal in 1995, note the capital outflows include the variations of central bank's reserves as it is assumed in the model.

Table 24: Explanation of Trade Variations

Year	Exports	Imports	Trade	ΔExports	ΔImports	ΔTrade	Capital Flows	ΔCapital Flows	GNI Growth
1993	18311.4	-19739.4	-1428.0						
1994	15485.4	-19029.7	-3544.4	-2826.1	709.6	-2116.4	1387.4	1387.4	4.7%
1995	21275.1	-21396.7	-121.6	5789.8	-2367.0	3422.8	-1475.5	-2862.9	-0.7%
1996	19232.3	-21037.5	-1805.1	-2042.8	359.3	-1683.6	1082.3	2557.8	4.2%
1997	13780.7	-19411.9	-5631.2	-5451.6	1625.6	-3826.1	2306.7	1224.4	5.8%
1998	12543.2	-19244.2	-6701.0	-1237.4	167.7	-1069.8	1023.9	-1282.7	3.5%
1999	**20490.3**	-22395.7	**-1905.5**	7947.0	-3151.5	4795.5	**-2040.8**	-3064.7	-0.8%
2000	24587.5	-24233.3	354.2	4097.3	-1837.6	2259.6	-899.4	1141.4	0.5%
2001	31297.1	-26982.3	4314.8	6709.5	-2748.9	3960.6	-1887.5	-988.1	-2.0%
2002	40238.0	-30174.8	10063.2	8940.9	-3192.5	5748.4	-3006.3	-1118.8	-7.6%
2003	**37671.5**	-30160.2	**7511.3**	**-2566.5**	14.6	-2551.9	**1126.9**	4133.2	6.8%
2004	34172.1	-29673.6	4498.4	-3499.4	486.5	-3012.9	1499.6	372.7	6.7%
	In thousands of 1993 local currency								

The first trade reversal happens in year 2000 following a large capital outflow of 11.0% of the GDP in 1999. In the year 2000, trade balance reverses to a surplus from a deficit as exports increases to \$24587.5 in year 2000 from \$20490.3 in year 1999. Imports decline -\$1837.6

Capital outflows continue until 2002 when the trade account reaches a maximum \$10,043.2 in local 1993 pesos. After that year, capital inflows grow and trade account reduces until the end of the study period.

A steady flow of imported intermediate goods in the model around the 2000 year has helped to lead a trade reversal as exports increases while imports maintain a constant value. This is a key feature of the models to replicate data properly.

5.2 Model Stationarity and Steady States

Although the focus of the study is to assess the models abilities to match the data for the short-term macroeconomic fluctuations for two periods, a capital flows stable 1940-1951 and a volatile 1993-2004, an analysis of the per worker steady-state values is included in order to evaluate the recovery of the economy after a country risk shock.

The study of steady states also allows to assessing and calculating the long-run multiplier effects on output and out productivity of the share of physical capital on GNI, denoted by α, and of the intensity use of intermediate goods σ in the final good production. Both parameters were estimated in the Calibration section.

The Solow and Ramsey models for a small open economy show incomplete asset markets as the modeled household has access to a single foreign asset, rather than having access to a complete array of claims. Then, the time series might be non-stationary, and the steady-state values of the model, if they exist, may depend on the initial values of the foreign asset stock A^f, and on the exogenous foreign rate of return r^f. In the Ramsey model as a consequence of asset market incompleteness, the Euler equation is a function of the exogenous τ_t country risk, which is variable over time.

However, the models' market incompleteness does not generate non-stationary time series as I reject it using standard and augmented Dickey Fuller tests.

Therefore, the model series and actual series are stationary, and there is no random walk; steady-state values exist. Under this condition, the numerical solution of the Ramsey model of the local approximation technique around the steady-state per effective worker values that is used to compute the initial value of consumption per effective worker is, therefore, valid. The Roe et al (2009) methodology that is used in this study does not generate non-stationary modeled time series, which are free of random walks for the study models.

Using this stationary property as short-run τ shocks at the start of the model lifetime do not make the model variables wander around the steady states positions, the short-run τ shocks have not long-run effects on the steady-state values of the economy.

Then, to simplify calculations, the country risk τ and the rate of return of the foreign asset r^f are assumed to be zero after the 12-year period under study, in periods 1940-1951 and 1993-2004, until the steady state is reached.

In the short run, $0 < t < 12$, there are non-zero τ shocks and positive constant $r^f > 0$ for the models as it is described in the model set up chapter 3.

In addition, the foreign rate of return r^f assumed zero $r^f = 0$ for $t > 12$, cancels any payment for holding remaining (non-zero) foreign assets A^f for $t > 12$ until the steady state.

5.3 Multiplier Effects of Intermediate Good Use

5.3.1 Design of the Experiment

I show two economy model simulations from initial t=0 until a steady state: an economy that uses domestic and import intermediate goods as input in the gross domestic production and an economy that does not use or cannot use the domestic intermediate goods in the domestic production.

The calibrated Ramsey model is used for the simulations from the period 1993-2004 to steady state for a small open economy. The two simulations are calibrated with the same parameters except for the intermediate good-to-gross production ratio $\sigma = 24.6\%$ and $\sigma = 0$ respectively and are subject to the same country risk shocks τ_t, from time $t = 0$ until $t = 12$ as in the validation Table 18, Chapter 4. This is identified as a transient state which is followed by a path after time $t > 12$ that there are, by assumption, no country risk shocks $\tau_{t\,>12} = 0$ and no capital mobility $CF_{t\,>12} = 0$ until a steady state is reached.

Multiplying effects are shown from the numerical comparison of steady-state values of the baseline simulation $\sigma = 24.6\%$ compared with the alternative simulation $\sigma = 0$. All variables are in per effective worker terms noted with a hat.

5.3.2 Analytical Framework

The gross final good production for scenario $\sigma = 0$ is

$$\hat{y}_f^{\sigma \neq 0} = \hat{w} + r^k \hat{k}_y + \hat{y}_i \tag{171}$$

A fixed proportion of intermediate good input-to-final good production results from the calibrated Ramsey model:

$$\hat{y}_i = z \ \hat{y}_f^{\sigma \neq 0} \tag{172}$$

Plugging equation (172) in the equation (171) the gross domestic production for the scenario $\sigma = 0$ is

$$\hat{y}_f^{\sigma \neq 0} = \hat{w} + r^k \hat{k}_y + z \ \hat{y}_f^{\sigma \neq 0} \tag{173}$$

By algebra

$$\hat{y}_f^{\sigma \neq 0}(1 - z) = \hat{w} + r^k \hat{k}_y \tag{174}$$

The left-hand side of equation (174) is the gross final good production for the economy $\sigma = 0$

$$\hat{y}_f^{\sigma \neq 0} \ (1 - z) = \hat{y}_f^{\sigma = 0} \tag{175}$$

Then, the final good productions relation is

$$\frac{\hat{y}_f^{\sigma \neq 0}}{\hat{y}_f^{\sigma = 0}} = \frac{1}{(1 - z)} \tag{176}$$

In both simulations, the fixed proportion of intermediate goods z is equal to the share usage σ of intermediate goods as inputs, $z = \sigma$

$$\frac{\hat{y}_f^{\sigma \neq 0}}{\hat{y}_f^{\sigma = 0}} = \frac{1}{(1 - \sigma)} \tag{177}$$

For a numerical example, plugging the share $\sigma = 0.24$ into equation (177), the multiplier is

$$\frac{\hat{y}_f^{\sigma\neq 0}}{\hat{y}_f^{\sigma=0}} = 1.327 \tag{178}$$

The exports of final goods when $\sigma \neq 0$ is

$$e\hat{x}p^{\sigma\neq 0} = \hat{y}_f^{\sigma\neq 0} - \hat{q} - \dot{\hat{k}}^d - \hat{k}_d\ (\delta + x + n) \tag{179}$$

The imports per effective worker are

$$i\hat{m}p^{\sigma\neq 0} = \hat{y}_i^{\sigma\neq 0} - \hat{y}_i^{\sigma\neq 0} \tag{180}$$

where y_i is per worker intermediate good production, and $\hat{y}_i$ is intermediate good input.

The exports of the final goods for scenario $\sigma = 0$ is

$$e\hat{x}p^{\sigma=0} = \hat{y}_f^{\sigma=0} - \hat{q} - \dot{\hat{k}}^d - \hat{k}_d\ (\delta + x + n) \tag{181}$$

Then, the balance of exports for the two economies as $\hat{q}$, $\hat{k}^d$, and the model parameters are identical for the models, from equations (179) and (181) is:

$$e\hat{x}p^{\sigma\neq 0} - e\hat{x}p^{\sigma=0} = \hat{y}_f^{\sigma\neq 0} - \hat{y}_f^{\sigma=0} \tag{182}$$

The balance of imports of the two economies is, according to equation (180)

$$i\hat{m}p^{\sigma\neq 0} - i\hat{m}p^{\sigma=0} = \hat{y}^{\sigma\neq 0} - \hat{y}_i^{\sigma\neq 0} - (\hat{y}^{\sigma=0} - \hat{y}_i^{\sigma=0}) \tag{183}$$

as $\hat{y}_i^{\sigma=0} = 0$ and $\hat{y}^{\sigma\neq0}$ is equal to $\hat{y}^{\sigma=0}$, then

$$i\hat{m}p^{\sigma\neq0} - i\hat{m}p^{\sigma=0} = -\hat{y}_i^{\sigma\neq0} \tag{184}$$

If the intermediate good usage is σ then, the gross final good production, the final good capital productivity, and final good labor productivity are multiplied by $\frac{1}{1-\sigma}$, which are generated by a virtuous cycle of economic growth towards the steady state. See steady-states values in Table 25. An increasing use of intermediate goods as input in the final good production matters, rather than the total domestic production of intermediate goods, to generate bigger multipliers.

Charles Jones (2011) interpreted the economic growth without intermediate goods as, "The growth theory is that an increase in total factor productivity raises output, which leads to more capital, which leads to more output and so on. If the share of capital in a Cobb-Douglas technology is α, the accumulation of this virtuous circle is $1 + \alpha + \alpha^2 + \alpha^3 + ... = \frac{1}{1-\alpha}$".

The use of intermediate goods generates an extra multiplier: higher output leads to more higher intermediate good quantity, which raises output (and capital) and so on. If the elasticity coefficient between intermediate- good input and capital is σ, the total factor productivity multiplier is $\frac{1}{(1-\alpha)(1-\sigma)}$, not just $\frac{1}{(1-\alpha)}$.

Jones (2011) explains how the multiplier help us to understand the propagation of business cycles, and the speed of the transition dynamics to the steady state, which is used in this study.

A key insight is that small open economies should increasingly use intermediate goods in the domestic good production to generate steady-state multipliers within industries. Increasing σ has three benefits: increasing multiplier, complementing the decline in physical capital stock with intermediate goods because capital outflow

Table 25: Multiplier Effects on Steady-State Values

Variable		Steady-state Values[1] σ = 24.6%	σ = 0	Multiplier effects: Steady State Relation[4]	
Country Risk shocks	τ_{ss}	0	0		
Gross Final-Good Output	$Y_{final,ss}$	**$170,140**	**$128,216**	**1.327^2 =**	$\frac{1}{1-\sigma}$
Intermediate-Good Demand	$Y_{i,ss}$	$41,923	0		
Final-Good Trade	Exp (Imp)	**$17,529**	**($24,394)**	$Y_f^{\sigma?0} - Y_f^{\sigma=0}$ =	$41,923
Intermediate-Good Trade	Exp (Imp)	**($17,529)**	**$24,394**	$-Y_i^{\sigma?0}$ =	($41,923)
Trade Balance		0	0		
Output Productivity					
Final-Good Capital Productivity	$Y_{final,ss}/K_{final,ss}$	**1.399**	**1.054**	**1.327^2 =**	$\frac{1}{1-\sigma}$
Final-Good Labor Productivity	$Y_{final,ss}/w_{ss}$	**1.697** [3]	**1.279**	**1.327^2 =**	$\frac{1}{(1-\alpha)(1-\sigma)}(1-\alpha) = \frac{1}{1-\sigma}$

1 Per-effective worker terms in 1993 million local currency.
2 Multiplier factor of use scenario over no-use steady-state values.
3 Multiplier effect is 1/(1-α)(1-σ)

effects, and larger exports.

5.3.3 Numerical Results

Table 25 shows the multiplying effects on steady-state values of gross final good output and final good capital and labor productivities.

The theoretical economy, which does not use intermediate goods to produce final goods, exports the entire local production of intermediate goods to a foreign country. It imports final goods to complete the final good demand. This economy depends on the importation of final goods for economic growth.

In the economy, that produces final goods at $\sigma = 24.7\%$, the local demand of intermediate goods is larger than the locally produced intermediate goods; hence the shortfall is imported from abroad. Economic growth largely depends on increasingly intermediate goods imports as this study shows in Chapter 2.

The larger intermediate good share σ is in the final good production the larger is the multiplying effects on the final good production, under a virtuous cycle that increase final good production, physical capital productivity and labor productivity. Physical capital productivity is defined as the quotient of final good production and capital: $\frac{Yf}{K_d}$. Labor productivity is the quotient as the final good production and wage: $\frac{Yf}{Wage}$.

The analytical expression for the multiplier a la Jones is obtained from the steady-state gross final good productions with and without input of intermediate goods.

Table 25 shows the gross final good production is $\frac{1}{(1-\sigma)} = 1,327$ larger than the final good production that does not use intermediate goods, $\sigma = 0$. The multiplier effect for this model is $\frac{1}{(1-\sigma)}$, same as Charles Jones (2012) suggested. Added multiplying effects are on the output-to-capital and to-labor productivities that are increased by the $\frac{1}{(1-\sigma)}$ multiplier. Intermediate goods as input do not affect the remaining steady states values that Table 25 does not show.

Exports for the theoretical economy are 39% larger than for the economy that uses intermediate goods as the economy exports the entire intermediate good production, which is not (or cannot be) locally used. The assumption is that, in the steady state, there are no capital flows ($\tau^{ss} = 0$), so the steady-state trade balance is zero.

The Argentinean economy features a strongly (negative) correlation coefficient -0.92 between importation of intermediate and capital goods, which the model mimics. Intermediate goods and capital goods are essentially the same kind of goods in economics, except for their accounting depreciation periods; a period for intermediate goods and several periods for capital goods.

Consumption growth is equal for both economies as the Euler equation does not depend on σ as the domestic saving rate, and the physical capital does. However, the economic growth processes of the simulations are quite different on reducing the economy vulnerability to capital flow effects as the Ramsey model uses the complementary feature of goods to offset costs.

The baseline economy that uses intermediate goods as an input for final good production using the complementary feature with capital goods can compensate production costs when physical capital decreases (i.e. when country risk jumps up generating capital outflows). It can import added capital goods to replace intermediate goods.

The economy that does not (or cannot) use its intermediate goods cannot compensate production costs to offset decreases in physical capital. It cannot even import capital goods after a capital outflow. Both economies are vulnerable to trade reversals in the 1993-2004 period as their dependency on imports; the small open economy depends on intermediate goods imports and the basic economy on final good imports. Sudden stops of large capital flows may still induce trade reversals.

6 Model Simulations

6.1 Introduction

The objective is to study the transition path of three economy scenarios, one with prolonged capital inflows, one with prolonged capital outflows, and an economy where capital flows are not allowed. The two capital flow economies are compared to the no-flow baseline for the first twelve years. A fourth scenario is an economy that while running a trade-balance deficit is hit by a transient country risk $\tau < 0$ shock (generating a capital outflow) in the fifth year that stops in the next period.

The calibrated Ramsey model, under free trade and capital flow mobility simulates four economies. At each simulation, an impulse country risk shock hits the economy, a capital flows step function at $t = 0$ that remains constant for every time $0 < t < 12$.

The first simulation is the impulse response to a country risk shock $\tau = 0.2$ at $t = 0$ which generates permanent capital inflows; the second impulse response is to country risk $\tau = -0.2$ at $t = 0$, generating permanent capital outflows. The third simulation involves no-flows $\tau = 0$, which is the baseline to compare the impulse responses.

The calibrated Ramsey model computes the impulse responses of macrovariables that are compared with the no-flow path baseline. The intensity use of intermediate goods is the estimated $\sigma = 24.6\%$ for the four simulations.

6.2 Macroeconomic Impulse Responses

6.2.1 Physical Capital Impulse Response

Table 26 shows physical capital impacts from country risk shocks and the effects of capital flows. Significant differences in the response of the capital flows-to-GNP

Table 26: Ramsey Model - Physical Capital Impact - 1993-2004

	Capital Inflow Scenario Trade Deficit Economy		No Capital Flow Baseline Economy		Capital Outflow Scenario Trade Surplus Economy	
	Average Rate[1]	Period Growth[2]	Average Rate[1]	Period Growth[2]	Average Rate[1]	Period Growth[2]
Country Risk Shock τ	0.2	0	0	0	-0.2	0
CF/GDP (%)	5.2%	13.4%	0	0	-3.2%	2.1%
National Saving Index	50.4	-10.3%	100.0	26.5%	129.7	32.6%
Domestic K Index	106.8	56.1%	100.0	39.9%	94.5	27.9%
Final K Index	74.0	51.7%	70.1	38.5%	66.9	28.5%
Intermediate K Index	32.8	66.7%	29.9	43.2%	27.6	26.4%
Domestic K / Worker Deepening Index	106.5	18.6%	100.0	6.3%	94.7	-2.8%
Rate of Return of Domestic K (%)	11.3%	-10.5%	11.7%	-3.9%	12.1%	1.9%

1 Percent Average Rate or Index compared to baseline.
2 Percent Period Growth Rate (start to end).

ratios arise for the trade-balance deficit economy, which grows 13.4%, and for the trade-balance surplus economy 2.1%.

Capital inflows are invested in domestic physical capital by households who then rent it to firms. Capital inflows raise the capital for final good and intermediate goods by 51.7% and 66.7% respectively. Capital deepening grows 18.6%, and domestic saving falls 10.3%.

Capital outflows reduce the investment in physical capital, in final and intermediate goods, which decline 28.5% and 26.4% respectively. Capital deepening falls 2.8%, and domestic saving grows 32.6%.

A key result is though the share of final- and intermediate good capital to domestic capital is equal for the three scenarios (70%/30%) the domestic capital growth for the capital inflow simulation is two times larger than the trade-balance surplus economy: 56.1% versus 27.9%.

Although σ is equal for the three scenarios, the capital growth of intermediate good for the capital outflow simulation is 26.4%, which constrains the intermediate good

Table 27: Ramsey - Production Output Impact - 1993-2004

	Capital Inflow Scenario Trade Deficit Economy		No Capital Flow Baseline Economy		Capital Outflow Scenario Trade Surplus Economy	
	Average Rate[1]	Period Growth[2]	Average Rate[1]	Period Growth[2]	Average Rate[1]	Period Growth[2]
Final-Good Output Index	101.2	35.7%	100.0	33.1%	99.0	30.9%
Intermediate-Good Output Index	104.9	49.2%	100.0	37.6%	95.9	28.8%
Intermediate-Good Demand Index	101.2	35.7%	100.0	33.1%	99.0	30.9%

1 Percent Average Index compared to baseline.
2 Percent Period Growth Rate (start to end).

production and exportation of final goods. Note that growth of the intermediate good capital for the trade-balance deficit economy is 66.7%, greater than the final good capital growth. As the intermediate good production is a key ingredient for economic growth for the multiplier that they generate, the capital deepening is 6.5% (see 106.5 index). The capital deepening for the trade-balance surplus economy is -5.3% (see 94.7 index) as intermediate good capital rises 26.4%.

The marginal product of total domestic capital for the trade-balance deficit economy contracts 10.5% as physical capital rises. For the trade-balance surplus economy, the marginal product grows 1.9%.

6.2.2 Production Output Impulse Response

Table 27 shows how capital outflows, after inducing the reduction of physical capital, reduce output of final and intermediate goods, compared with no-flow scenario. Output period growth 30.9% is slower than in the no-flow simulation, 33.1%. Multipliers generated by the intermediate goods use ties the growth rate of intermediate good and final good output for the three scenarios, 35.7%; 33.1% and 30.9% respectively.

For the trade-balance deficit economy, intermediate good output growth 49.2% is greater than the combined growth of final output and intermediate good demand

35.7%, which is produced by the greater impact of capital flows on intermediate good capital than on final good capital. See Table 26.

6.2.3 Trade Impulse Response

The Ramsey model simulations compute imports that only are intermediate goods, and exports that only are final goods for the three scenarios. Intermediate good demand for the final good production is greater than the domestic production. The domestic production of final goods is greater than the domestic demand thus the surplus is exported.

In Table 28, the capital outflow economy shows a trade-balance surplus of 3.2% of GDP that is financed by exporting saving from households' income. The capital outflow economy exports added 26.9% (see 126.9 index) if it compared with the no-flow economy; exports grow at 32.2% that is 4.2 percent basis points greater than the no-flow economy of 28.0%.

The larger export growth for the capital outflow economy can explain the quicker recovery that, an economic that runs a trade-balance surplus displays when it is shocked by country risk. Added capital outflows rise exports and increase the GDP growth to 4.2% during the simulation period. Thus, the trade-balance surplus economy is an export-led growth economy.

Instead, the trade-balance deficit economy behaves as an inward growth-oriented economy; a lower proportion of output level is set aside for exportation that is mostly allocated to domestic consumption. Total exports for the trade-balance deficit economy is 55.4 of the no-flow economy and grow slowly at 0.5%, which is $\frac{1}{60}$ of the export growth for the trade-balance surplus economy. GDP growth falls 11.8%. Sources of greater exports are lesser domestic consumption and lesser investment in physical than the capital inflow economy can absorb.

Table 28: Ramsey - Trade Impact - 1993-2004

	Capital Inflow Scenario		No Capital Flow		Capital Outflow Scenario	
	Trade Deficit Economy		Baseline Economy		Trade Surplus Economy	
	Average Rate[1]	Period Growth[2]	Average Rate[1]	Period Growth[2]	Average Rate[1]	Period Growth[2]
Total Exports Index (final goods)	55.4	0.5%	100.0	28.0%	126.9	32.2%
Total Imports Index (intermediate goods)	96.9	20.9%	100.0	28.0%	102.5	33.2%
Exp/GDP (%)	7.1%	-27.0%	12.9%	-4.3%	16.6%	1.2%
Imp/GDP (%)	12.3%	-12.2%	12.9%	-4.3%	13.4%	2.0%
Trade Balance[3]	-$9.0	-56.1%	0	0	$5.3	27.9%
Annual Trade Growth (%)	4.1%	29.1%	0	0	2.3%	19.0%
Trade/GDP (%)	-5.2%	-13.4%	0	0	3.2%	-2.1%
Annual GDP Growth (%)	3.0%	-11.8%	2.7%	-6.2%	2.5%	4.2%

1 Percent Average Rate or Index compared to baseline.
2 Percent Period Growth Rate (start to end).
3 In billion pesos and percent period growth rate compared to baseline

Average export-to-GDP ratio is 7.1%, lower than the two other economies, (12.9% and 16.6%) and declines at a growth rate of 27.0% in the period. The exports level declines when prolonged capital inflows develop as the export-to-GDP ratio growth declines half of the no-flow economy. However, annual average GDP grows at 2.95% at a greater growth rate than the capital outflow economy 2.46%. See Table 29. The more the trade-balance deficit economy is shocked by country risk (capital inflows) the lesser the exports are the greater the GDP growth rate if compared with the no-flow economy.

Trade-to-GDP ratio is a deficit of 5.2% that declines at 13.4% during the period; the trade-balance deficit is financed by added capital inflows.

The capital outflow economy is the single scenario where the GDP grows 4.2% a year. The more the trade-balance surplus economy is hit by capital outflows exports rise, and the lesser GDP growth, compared to the no-flow economy. The GDP growth rates of the two other scenarios decline at 11.8% and 6.2% respectively.

Import growth rates are for the capital outflow economy 2.0%, for no-flow −4.3%, and capital inflow economy −12.2%. However, average Import-to-GDP ratios are

Table 29: Ramsey - Marginal Products and Income - 1993-2004

	Capital Inflow Scenario Trade Deficit Economy		No Capital Flow Baseline Economy		Capital Outflow Scenario Trade Surplus Economy	
	Average Rate[1]	Period Growth[2]	Average Rate[1]	Period Growth[2]	Average Rate[1]	Period Growth[2]
Country Risk Shock τ	0.2	0.0%	0.0	0.0%	-0.2	0.0%
Investment in Domestic K Index	127.1	24.7%	100.0	26.51%	84.4	35.3%
Rate to return to Domestic K (%)	11.3%	-10.5%	11.7%	-3.9%	12.1%	1.9%
Wage Index	101.1	13.9%	100.0	11.7%	99.0	9.8%
Wage / Worker Index	92.1	-12.5%	100.0	-15.4%	98.0	-15.1%
Consumption / Worker Index	103.4	6.8%	100.0	2.3%	97.3	-1.1%
Consumption / Wage Ratio Index	102.0	24.7%	100.0	21.1%	98.5	18.3%
Gross National Income Index	94.9	36.5%	100.0	33.7%	102.6	30.5%

1 Percent Average Rate or Index compared to baseline.
2 Percent Period Growth Rate (start to end).

similar for the three scenarios.

The trade-balance surplus economy absorbs average Imports-to-GDP ratio at 13.4% that grows at 2.0% as exports are 16.6%. The trade balance is a surplus.

The capital inflow economy runs a deficit growing −56.1% for the period; exports increasing 7.1% and imports 12.3%.

6.2.4 Marginal Products and Income Impulse Responses

In the capital inflow scenario, the marginal product of physical capital falls as investment in capital increases, and wage increases enough to raise gross domestic product. The consumption per worker and consumption-to-wage ratio rise so the purchasing power of the workers rises if compared with the two scenarios.

In the capital outflow scenario, wage declines, purchasing power declines and GDP falls. See Table 29 and 27.

Table 30: Ramsey - Output Impact - 1993-2004

	Capital Inflow Scenario Trade Deficit Economy		No Capital Flow Baseline Economy		Capital Outflow Scenario Trade Surplus Economy	
	Average Rate[1]	Period Growth[2]	Average Rate[1]	Period Growth[2]	Average Rate[1]	Period Growth[2]
GDP Index	101.7	37.7%	100.0	33.7%	98.5	30.6%
GNP Index	94.9	36.5%	100.0	33.7%	102.6	30.5%
GDP per worker Index	101.8	4.0%	100.0	1.3%	98.5	-0.7%
Annual GDP Growth (%)	3.0%	**-11.8%**	2.7%	-6.2%	2.5%	**4.2%**
Physical Capital/Output Index	2.4	13.4%	2.3	4.6%	2.2	-2.1%

1 Percent Average Rate or Index compared to baseline.
2 Percent Period Growth Rate (start to end).

6.2.5 GDP Impulse Response

In Table 30, the GDP for the trade-balance deficit economy grows 37.7%, which is greater than the GDP growth rates for no-flow and trade-balance surplus economies. This is the result of increasing investment in physical capital, increasing wage and increasing output of the final and intermediate goods as well as increasing consumption.

However, the single GDP that grows is in the trade-balance surplus economy at an annual rate 4.2%. Other GDP growth rates decline at -6.2% for the no-flow economy and -11.8% for the trade-balance deficit economy.

The GDP per worker for the trade-balance surplus economy decreases as capital flows continue outgoing, at a period rate -0.7%. The GDP per worker for the trade-balance deficit economy increases as capital flows continue incoming, at a period of 4.0%.

The average physical capital-to-output ratio is similar for the three scenarios. However, the growth rate ratio is 13.4% of trade-balance deficit economy in the period (3 times the no-flow growth ratio), and growth ratio for the trade-balance surplus economy declines -2.1% as physical capital continue declining.

Table 31: Saving Rate Impulse Response

Year	1993	1997	2001	2004
Trade-Deficit Economy				
Consumption[1]	$121.7	$139.5	$158.2	$172.9
Saving[1]	$14.5	$13.6	$13.1	$13.0
Saving/GNI[2]	10.62%	8.91%	7.68%	6.98%
No-flow Economy				
Consumption[1]	$121.3	$136.0	$151.5	$164.0
Saving[1]	$23.9	$25.9	$28.2	$30.2
Saving/GNI[2]	16.45%	15.99%	15.70%	15.56%
Trade-Surplus Economy				
Consumption[1]	$121.2	$133.0	$146.4	$157.5
Saving[1]	$30.1	$33.4	$37.0	$39.9
Saving/GNI[2]	19.89%	20.07%	20.17%	20.21%
1 1993 local currency in billions				
2 Percent national saving rate				

6.2.6 Consumption and Saving Rate Impulse Response

The simulation shows how the saving rate for the trade-balance deficit economy declines over time, which is the most significant disadvantage of prolonged capital inflows in the long-term. Alternatively, no-flow economy slightly decline, and the trade-balance surplus economy rises over time. See Figure 35 in Appendix, the slope of the saving rate for capital inflows is strongly declining.

Table 31 shows the yearly declining saving rate for the trade-balance deficit economy from 10.62% to 6.98%, which is lower than the two other simulations. As prolonged capital inflows disincentive households to save economic growth relies on external borrowing. The saving rate remained at historical low levels 6.45% in the long period 1900-1939 as it is shown in the empirical study in Chapter 2.

Consumption grows in the three scenarios. Aggregate consumption grows for the trade-balance deficit economy more than in the no-flow and trade-balance surplus economies. Saving is increasing as capital outflows continue and reduces consumption in trade-balance surplus economy. The saving rate grows to 20.21% by year 2004.

6.3 Economic Response to Transient Shock

6.3.1 Design of the Simulation

The objective is to show the GDP response to a transient country risk shock and its effects in the short run and long term. I use the calibrated Solow model to simulate the economy as under the Solow rule on saving rate, consumption is a fixed proportion of contemporaneous income, which is not an inter-temporal choice. Under these conditions, perfect financial markets assumption is not required for the consumption choice.[32]

The simulation shows an economy in which the country risk is stable, which develops a stable, annual capital inflow of 8.7% of GDP from $t = 0$ to $t = 3$. The trade-balance deficit is 8.7% of GDP. In $t = 4$, country risk jumps up 300 basis points, which develops a sudden capital outflow that lasts one period from. In $t = 5$ the initial stable country risk level resumes; stable capital inflows 8.7% of GDP and trade-balance deficit resume until steady state.

6.3.2 GDP Response to a Transient Country Risk Shock

The one-time, transient country risk shock in $t = 4$ makes the GDP fall 4.9% in $t = 5$ of the model. Consumption declines 2.2% in $t = 5$ investment drops 385.0% and trade balance reverses to a surplus from a deficit. Physical capital stock drops 23.0% in $t = 5$, increasing 7.6% in $t = 6$. Households' wealth rises 2.8% in a period.

Figure 1 shows that output does not return to the original path after the shock vanishes in the fifth period. The economy exhibits hysteresis effects that prevent the GDP to catch up to the original path to the steady state. Therefore, transient country risk τ shocks have long-run effects on the economy under incomplete asset

[32] The Ramsey model requires perfect financial markets for the inter-temporal consumption choice, represented by the Euler equation.

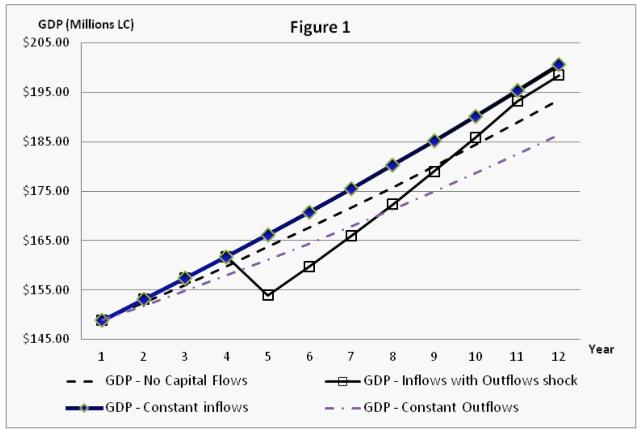

Figure 1: GDP Response to a Transient Shock

markets; there is a single foreign asset A_t^f to choose from, restriction that keeps the path below the path until GDP reaches steady state. For calibrated models, financial incompleteness slows down capital accumulation convergence to the steady state. Figure 1 shows the long-term effects of the idiosyncratic country risk in $t = 4$ on GDP.

The output size that is lost forever is measured by the discounted present value of the gap between both paths, which is estimated $49.9 billion pesos for the economy. It represents 33.5% of the 1993 GDP or $ 3.8 million pesos per worker for the entire model lifetime from $t = 0$ until steady state. It reflects the load households have to give up (or willing to pay) to have a better policy that addresses macroeconomic fluctuations from country risk shocks and greater capital flow volatility.

6.4 Policy Experiment on Saving Rates

6.4.1 Design of the Experiment

I present a policy experiment to isolate the factors that affect the GDP when the saving rate is increased to 60% from 30%. The calibrated Solow model with national

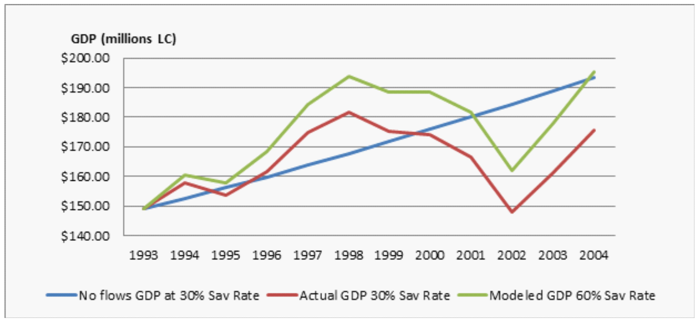

Figure 2: GDP Simulations

saving rate 30% is compared with a theoretical saving-to-GNI rate of 60%. A cost-benefit analysis measures the incremental gains and losses of the simulation from year 1993 to steady state. See Figure 1.

6.4.2 Analysis of Results

Table 32 shows the results of the 60% saving rate policy with the actual economy. The increase of the saving rate to 60% shows that volatility of trade and gross capital formation reduce to half of the 30% rate economy volatility. Volatility is measured as the standard deviation for the period 1993-2004. Note that trade and capital formation are the variables that are more impacted by capital flow volatility in the 30% domestic saving rate scenario. See Figure 2.

The discounted present value of the physical capital stock and capital deepening improve from -521.3% to 5915.9% and from -973.7% to 13814% respectively. GDP goes from -60.7 to 339.1% and per worker GDP from -34.8% to 263.1%. Labor productivity of the final good output $\frac{Yf}{w}$ improves from -29.9% to 34.8%.

Table 33 shows the incremental gains and losses of the 60% saving-rate economy compared with the 30% actual economy. The GDP for the 30% economy drops 7.8 percent basis points over the no-flow economy because of capital flow volatility; while the 60% saving-rate economy raises GDP 11.1% over the 30% saving economy.

Table 32: Policy Experiment on National Saving Rate Net discounted cash flow from 1993 year to steady state

	30% Saving Rate		60% Saving Rate	
	Discounted Present Value[1] (%)	Variable Volatility[2] (%)	Discounted Present Value[1] (%)	Variable Volatility[2] (%)
GDP	-60.7%	6.58%	339.1%	7.03%
GDP/worker[3]	-34.8%		263.1%	
GNI	-61.3%	4.40%	599.5%	4.26%
National Saving	-42.9%	4.40%	1342.3%	4.26%
Consumption	78.4%	4.40%	-4904.7%	4.26%
Gross Capital Formation	-48.2%	**2812.1%**	738.2%	**1239.7%**
Physical Capital Stock	**-973.7%**		**13814.1%**	
Capital deepening[3]	**-521.3%**		**5915.9%**	
Wages	-20.8%	0.41%	149.7%	0.42%
Final-Good Output Labor Productivity (Y^f/w)[3]	-29.9%	0.39%	34.8%	0.40%
Trade	-0.6%	**1634.5%**	2.9%	**865.1%**

1 As percent of 1993 GDP
2 Standard Deviation
3 As percent of 1993 GDP/worker

Table 33: Cost Benefit Analysis Accumulated Gains and Losses Period 1993-2004

	Actual Economy Over No Flow Economy	60% Sav Rate Economy Over Actual Economy
GDP growth rate[1]	-7.8%	11.1%
Rate of Return of Physical Capital[1]	7.3%	-10.4%
Physical Capital-to-Output Ratio	-3.69	10.32
1 Percent basis points		

The marginal product of physical capital is 7.3% for the 30% economy over the no-flow economy, and it falls 1040 basis points as the capital stock rises. Capital-to-output rises from 369 to 1032 basis points.

In summary, a larger saving rate improves levels of physical capital related variables, trade and output. It reduces volatility of two impacted variables: gross capital formation and trade. Consumption is the single variable that reduces in the 60% saving-rate economy if compared to 30% economy.

See Figure 36 in Appendix that shows the GDP with 30% and 60% saving rate and the no-flow economy GDP.

6.4.3 Behavior of Larger Saving Rates in Open Economies

The model simulation of the trade-balance surplus economy with larger saving rate shows that it protects the output growth, and reduce the output lost forever driven by τ shocks of capital outflows. In an open economy, the share of gross domestic saving to investment s_I is

$$s_I(G_d, I) \equiv \frac{Domestic\ Saving}{Investment} \tag{185}$$

Plugging in $Investment = Domestic\ Saving - Trade$

$$s_I(G_d, trade) = \frac{Domestic\ Saving}{Domestic\ Saving - Trade} \tag{186}$$

Plugging $CF = -Trade$

$$s_I(G_d, CF) = \frac{Domestic\ Saving}{Domestic\ Saving + CF} \tag{187}$$

The s_I for an economy that runs a trade-balance deficit assuming CF is given, and finite, and when s_d domestic saving tends to infinity is,

$$s_I^*(G_d, CF) = \lim_{s->\infty} \frac{Domestic\ Saving}{Domestic\ Saving + CF} = 1 \tag{188}$$

Then, equation (185)

$$s_I(G_d, I) \equiv \frac{Domestic\ Saving}{Investment} = 1 \tag{189}$$

The result is an open economy that looks like the behavior of a closed economy where domestic saving ratio is strong enough. In practice, if the saving rate is three times greater that a capital flows-to-output ratio, the economy is protected from capital flow volatility.

The larger the domestic saving is the lesser vulnerable a small open economy growth is to capital flow volatility. In this case, an open economy behaves as a closed economy does. Having a large domestic saving in small open economies that run a trade-balance deficit protects from large and sudden capital flow volatility.

7 Conclusions

The study analyzed the macroeconomic impact of country risk shocks and capital flow volatility in a small open economy.

Consider the productions of final and intermediate goods to understand how a decline in capital flows may reduce output. Withdrawing capital out of the economy to the foreign country lowers the domestic physical capital in both good productions. The marginal products of labor and the specific-endowment H are reduced in the goods production. This double shock to production affects domestic factor earnings and decreases the country's surplus trade balance.

The decline in returns to households' domestic resources, labor wages, and the specific-endowment H is counterbalanced to some degree by the increase in remuneration to the savings held abroad as well as the increase of the marginal product of the reduced physical capital. Therefore, gross national income departs from gross domestic product. The total gross income declines, which thus lowers the consumption level.

Exports grow as consumption, domestic saving, and final good production lower. The decline in consumption and physical capital are more pronounced than the decline in final good production because, the multiplier a la Charles Jones that is generated by using intermediate goods as inputs in the final good production.

The trade balance remains a deficit as long as capital outflows are withdrawing out of the economy. If the country risk lowers to receive capital inflows, country's trade balance reverts to a surplus as exports increase and imports fall. Domestic physical capital stock improves both productions of final and intermediate goods rise, and consumption increase.

In summary, capital outflows have multiplier effects on macroeconomics.It lowers the marginal product of labor, the physical capital investment, the final and intermediate good production, which in turn affect negatively the marginal product of labor, and it lowers the investment in physical capital in the next period, in a vicious feedback loop until steady state is reached.

The saving rate counter experiment shows that an increase of the domestic saving rate in a trade-balance deficit economy, economic growth is significantly improved, and macroeconomic volatility is reduced. Policy makers may use this theory to enforce public policies to incentive householders to save, and thus protecting the economy from further macroeconomic volatility that risks economic growth. Policies to complete the financial markets would reduce macroeconomic volatility and hysteresis effects of the idiosyncratic shocks. The saving behavior of households is key to understand in periods of economic growth under low volatility and the behavior under economic crisis with high volatility. Households, under shocks, save a fixed proportion of the contemporaneous income, regardless of the future.or permanent part of income.

The complementarity relationship between imported intermediate goods and capital goods is an effective feature for policy making to offset capital stock reductions. Advantages and disadvantages of economies, which run a trade-balance surplus or a deficit when facing capital flow volatility, can be used to reduce within and between economies' fluctuations.

This study opens a space to develop larger macroeconomic frameworks to research and propose policies to deal with the multiplying effects of country risk volatility and capital flows to economies. Commodity international prices would be incorporated in future studies, to show how trade flows influence macroeconomy volatility. Further, how trade flows and capital flows affect income distribution in the short and the long run. There is empirical evidence that commodity price volatility and speculative, high frequency capital flow volatility significantly affect the income distribution in the short run; then, extended research will significantly improve policy making and the society well-being.

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9 Appendix

9.1 Introduction

9.1.1 Balance-of-Payment Accounting

The Balance of Payments for the Solow and Ramsey models is

$$Current\ Account + Capital\ Account - \Delta R = 0 \tag{190}$$

where ΔR is the variation of central bank reserves.

The Current Account is equal to the Trade account plus the Services Account (real and financial) plus the Transferences among economies

$$Current\ Account = Trade\ Account + Services\ Account + Transferences \tag{191}$$

The national accounts are

$$GDP + Imports\ (goods\ and\ services) = \tag{192}$$

$$Consumption\ (private\ and\ public) + Exports\ (goods\ and\ services)$$

By algebra in previous equation (192)

$$Exports - Imports = GDP - Consumption - Investment \tag{193}$$

From equation (190), trade account is

$$Exports - Imports = \Delta R - Capital\ Account - Services\ Account - Transferences \tag{194}$$

The Capital Flows definition is

$$Capital\ Flows \equiv Capital\ Account + Services\ Account + Transferences \quad (195)$$

Then, from equation (195), Capital Flows results

$$Capital\ Flows = -(Exports - Imports) + \Delta R + R_n \quad (196)$$

where R_n is transferences among economies.

Equation (196) is the expression of capital flows for the Solow and the Ramsey models' analytical framework.

9.1.2 GDP and Capital Flows

GNI is

$$GNI = C + Gn \quad (197)$$

where C is consumption and Gn is national saving.

Gn is

$$Gn = Investment + \ Current\ Account \quad (198)$$

Plugging equation (195)

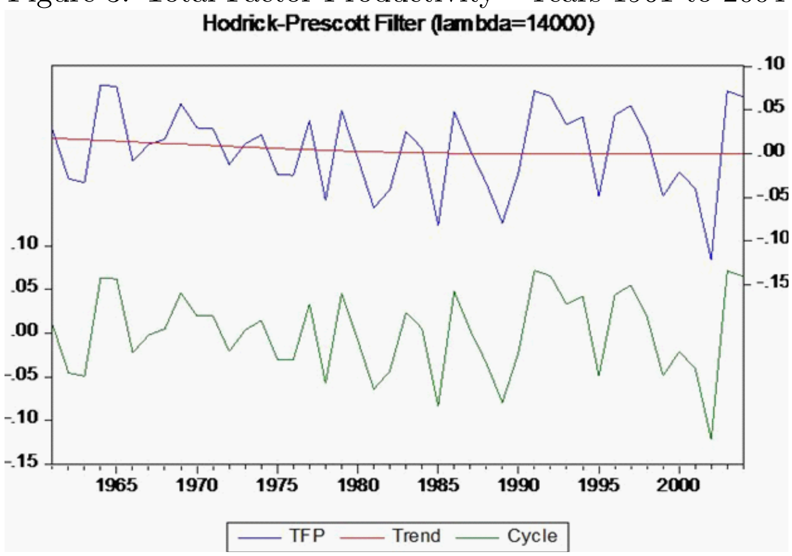
$$Gn = I - CF + \Delta R + R_n \quad (199)$$

9.2 Sources of GDP Growth

9.2.1 Total Factor Productivity Analysis

Figure 3 shows Total Factor Productivity cycles for years 1961 to 2004. The TFP trend is close to zero for five decades.

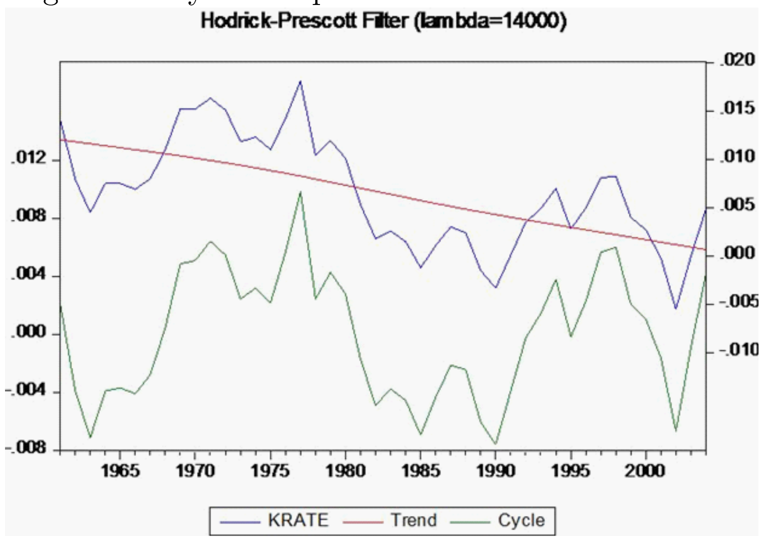
Figure 3: Total Factor Productivity - Years 1961 to 2004



TFP trend right scale.
TFP deviation left scale.

Physical Capital Stock from 1960.

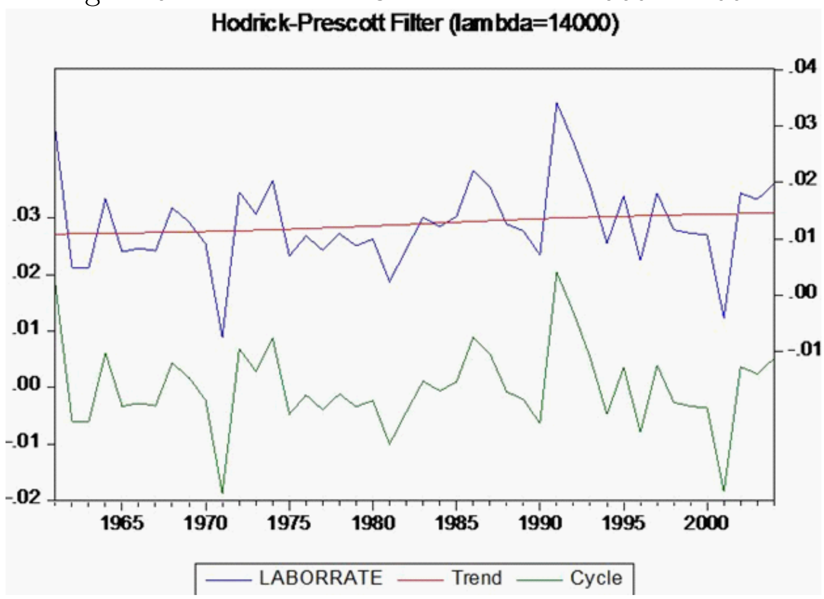
Figure 4: Physical Capital Stock - Years 1960 to 2004



Physical capital stock Growth Rate trend, right scale.
Physical capital stock Growth Rate deviation from trend, left scale.

Labor Force Growth Rate

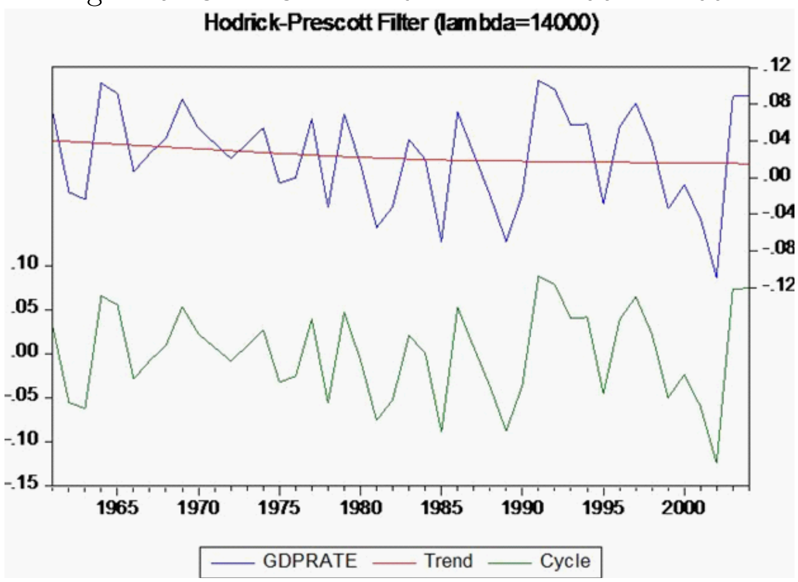
Figure 5: Labor Force Growth - Years 1960 to 2004



Labor Force Growth Rate trend, right scale.
Labor Force Growth Rate deviation form trend, left scale.

GDP Growth Rate from 1961 to 2004.

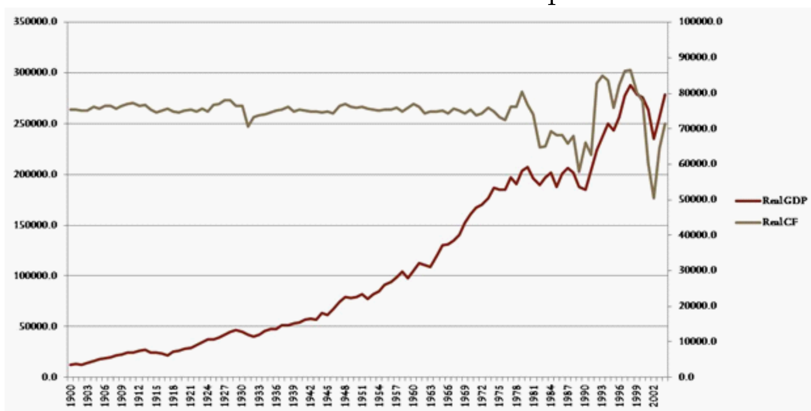
Figure 6: GDP Growth Rate - Years 1961 to 2004



GDP Growth Rate trend, right scale.
GDP Growth Rate deviation form trend, left scale.

Real Gross Domestic Product and real Capital Flows

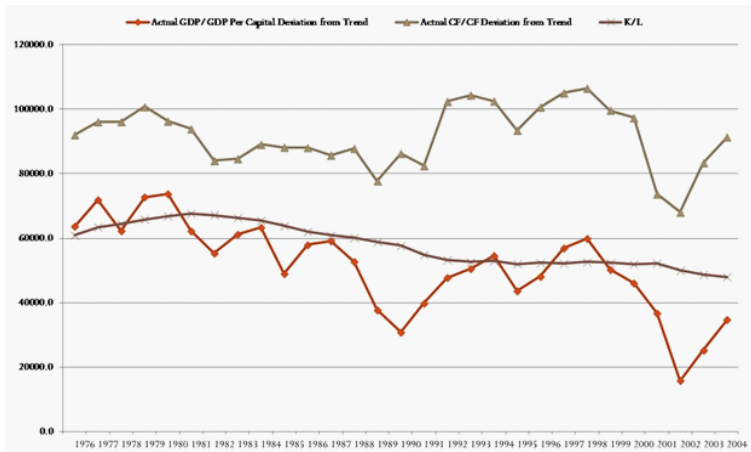
Figure 7: Real Gross Domestic Product and real Capital Flows - Years 1960 to 2004



Real GDP, left scale.
Real Capital Flows, right scale.

Figure 8 Actual GDP deviations, actual Capital flows deviations and Physical Capital per worker - Years 1976 to 2004

Figure 8: Real GDP deviations, real Capital Flows deviations and Physical Capital per worker



Note 3

Foreign, non-resident capital flows add to the resident capital flows so that macroeconomic fluctuations are enlarged. Thus, capital flow *changes* expand or contract domestic saving in a very short period of time, affecting the entire economy: investment in physical capital formation, domestic consumption, and government expenditures as well as export and import volume.

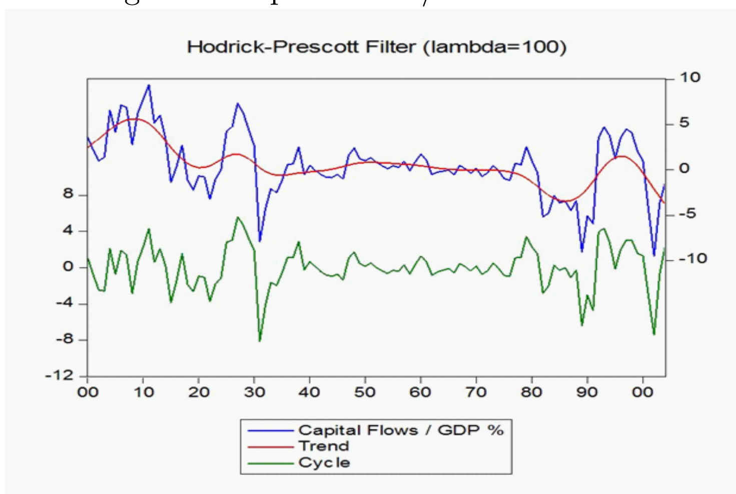
Central banks' policies to offset the size and volatility of the capital outflows are often constrained by the existing foreign reserves stock or by the limited access to international capital markets.

Note 4

Macroeconomists have been dealing on how capital flows affected the real economy. Diverse economic theories have been put forward to explain how the trade and balance-of-payments adjusts to capital flows as well as to world price shocks.

Capital Flows/GDP trend and deviation from trend since 1900 to 2004. Three periods of capital flow volatility, 1900 to 1940, 1941 to 1975 and 1976 to 2004

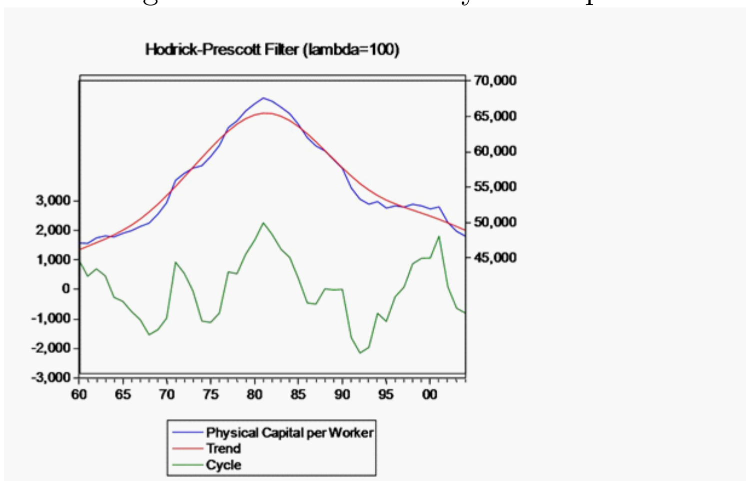
Figure 9: Capital Flows/GDP deviations



Capital Flows/GDP (%) trend right scale.
Capital Flows deviation from trend left scale.

Per-worker physical capital. Trend and deviation from trend. Years from 1960 to 2004

Figure 10: Per worker Physical Capital



Per-worker physical capital trend, right scale.
Per-worker physical capital deviation from trend, left scale.

9.2.2 Placing this dissertation in the literature

Note 3

Regarding the capital outflow of $43bn dollars in twelve months, from June 2008 to May 2009, it was the jump in country risk premium that droved the capital outflow shock. It was was equivalent to 85% of the central bank's reserves at that time.

Central bank reserves, or official loans, are eventually used in Argentina to partially or totally offset the sum of the current and capital accounts' imbalances and to intervene in order to restore equilibrium to the country's Balance of Payments.

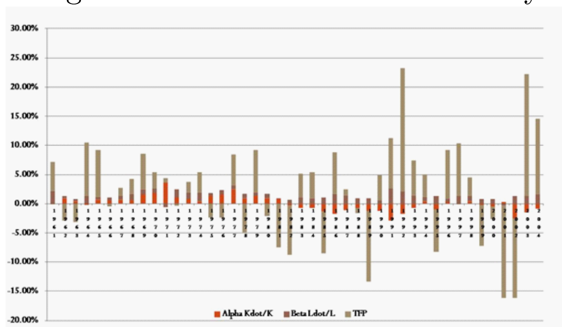
Note 4

Specific literature on capital flows and economic growth under the neoclassical framework is dispersed. Current literature is based on real macrovariables which do not integrate with the Balance of Payments that is the linkage between the national saving, and the capital flows.

The Real Business Cycle theory, by Hodrick and Prescott (1982) and Long and Plosser (1983), is an example of one that excludes foreign saving, and the Balance-of-Payments variables. On the other hand, there are Balance-of-Payment models that are not integrated with economic growth, i.e., Krugman (1979) and Calvo (1998). I integrate both concepts in the Solow and Ramsey models.

Total Factor Productivity Decomposition from 1910 to 2004

Figure 11: Total Factor Productivity



9.3 Chapter 2 Empirical Evidence

9.3.1 Investment Variance Decomposition per Period

$$I = S + CF - \Delta R - Rn \tag{200}$$

$$1 = \sum \frac{Variance\ (m_i)}{Variance\ (i)} + 2 \sum \frac{Covariance\ (m_j, m_i)}{Variance\ (i)} \tag{201}$$

where m_i represents the components of the investment equation 190

$$\begin{aligned} 1 \quad = \quad & \frac{Var\ (S)}{Var(i)} + \frac{Var\ (CF)}{Var\ (i)} + \frac{Var\ (\Delta R)}{Var\ (i)} + \frac{Var\ (Rn)}{Var\ (i)} + \\ & 2\frac{Cov\ (S, CF)}{Var\ (i)} + 2\frac{Cov\ (S, \Delta R)}{Var(i)} + 2\frac{Cov\ (S, Rn)}{Var\ (i)} + \\ & 2\frac{Cov\ (CF, \Delta R)}{Var\ (i)} + 2\frac{Cov\ (CF, Rn)}{Var\ (i)} + 2\frac{Cov\ (\Delta R, Rn)}{Var\ (i)} \end{aligned} \tag{202}$$

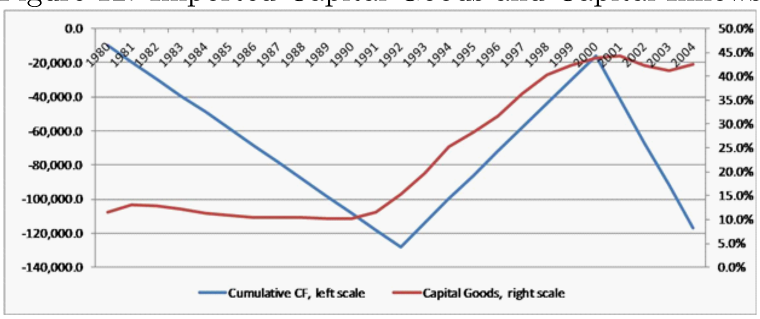
9.3.2 Capital Inflows, Imported Intermediate and Capital Goods

Imported Capital Goods and Capital Inflows.

Capital inflows and importation of capital goods stock share shows that capital inflows are strongly (positive) correlated to importation of capital goods in the period 1992-2000.

Contemporaneous Correlation coefficient: +0.99

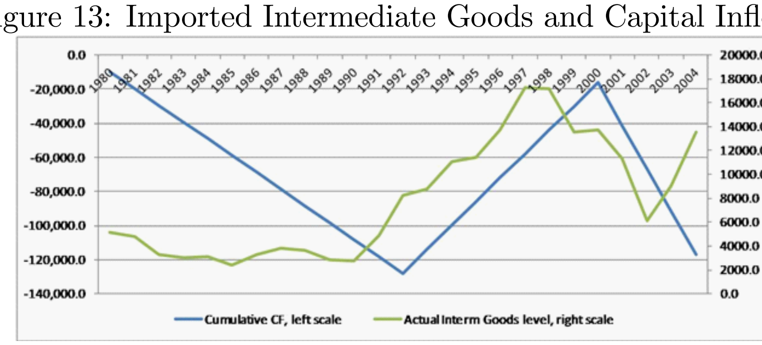
Figure 12: Imported Capital Goods and Capital Inflows



Imported Intermediate Goods and Capital Inflows.

Imported Intermediate goods are strong (positive) correlated to capital inflows, correlation coefficient +0.97 in the period 1992 to 1998.

Figure 13: Imported Intermediate Goods and Capital Inflows

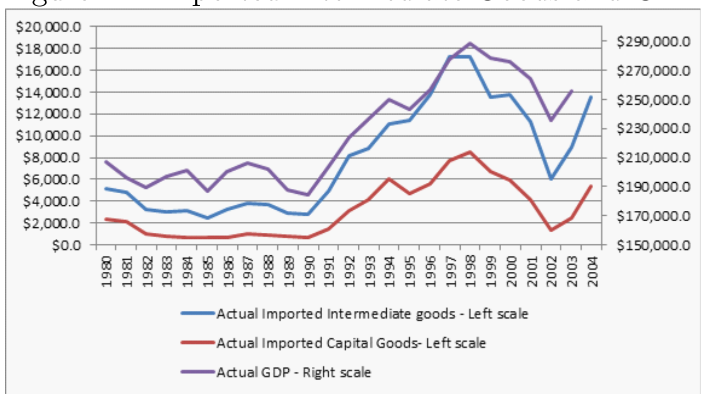


Imported Intermediate goods and GDP.

Imported intermediate goods levels follows GDP path.

Contemporaneous correlation coefficient for period 1980-2004: +0.92

Figure 14: Imported Intermediate Goods and GDP



9.4 Chapter 3

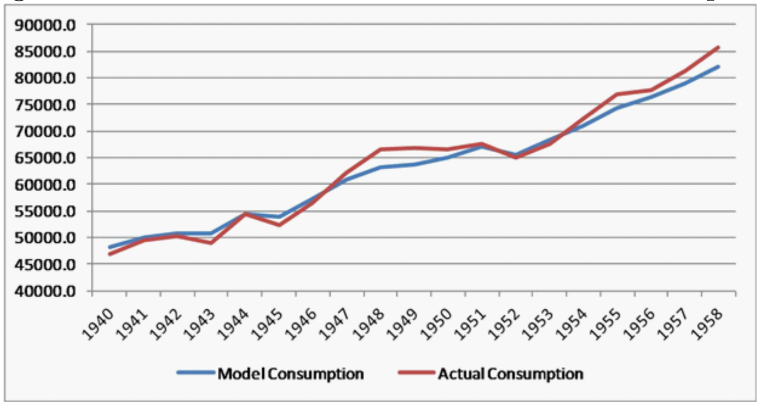
9.4.1 Validation Solow Models

Validation of Solow Model Period 1940-1951 All currencies in graphics are in millions of 1993 local currency.

Actual and Modeled Households' Consumption.

Contemporaneous correlation coefficient 1940-1951: 0.99

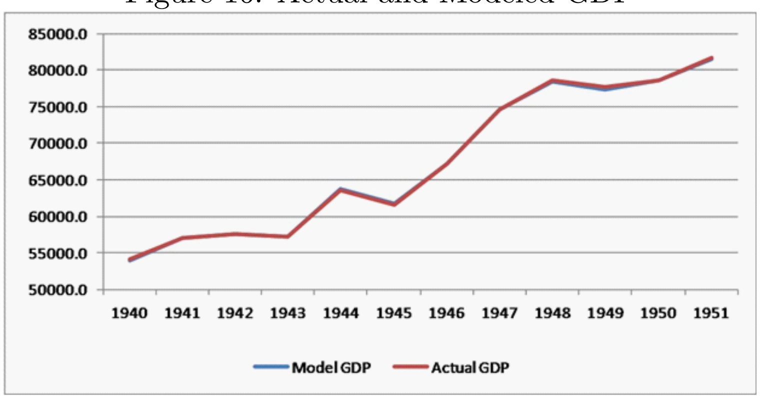
Figure 15: Actual and Modeled Households' Consumption



Actual and Modeled GDP

Contemporaneous correlation coefficient 0.99

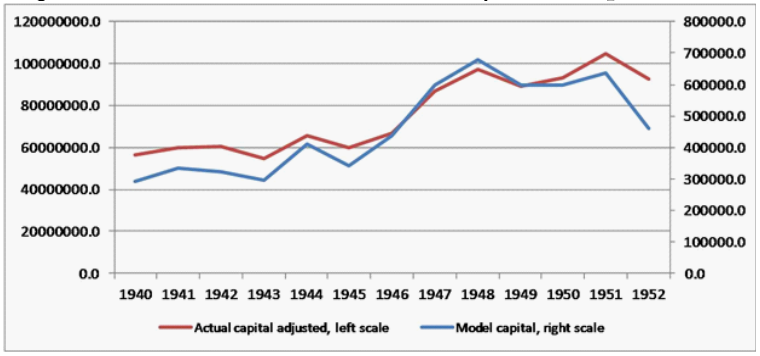
Figure 16: Actual and Modeled GDP



Actual and Modeled Physical Capital Stock

Contemporaneous correlation coefficient 1940-1951: 0.73

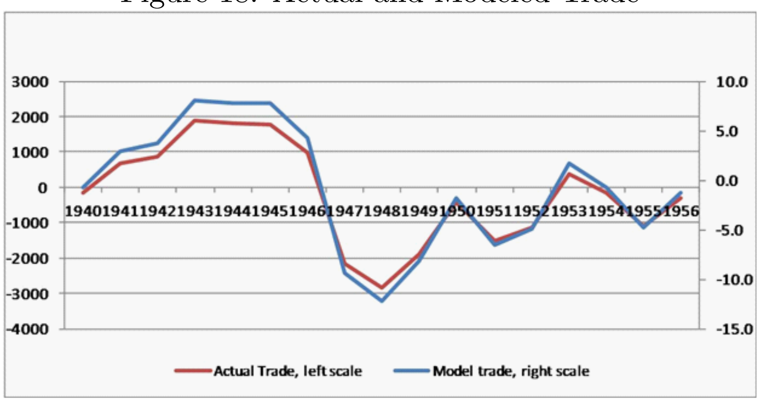
Figure 17: Actual and Modeled Physical Capital Stock



Actual and Model Trade. Trade reversal in year 1946.

Contemporaneous correlation coefficient 1940-1951 0.99

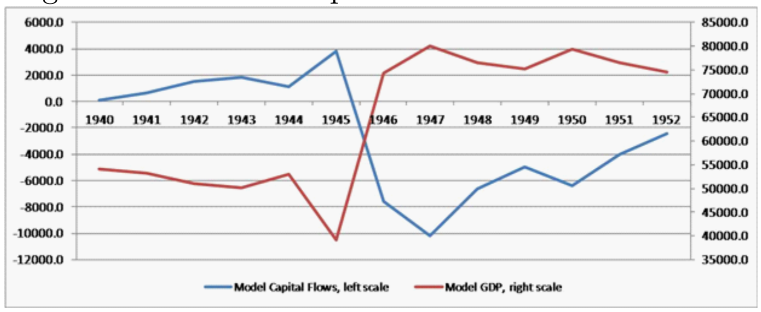
Figure 18: Actual and Modeled Trade



Model Capital Flows and Model GDP, which are in a counter-cycle relationship as shown in actual data.

Contemporaneous correlation coefficient 1940-1951: - 0.93

Figure 19: Modeled Capital Flows and Modeled GDP

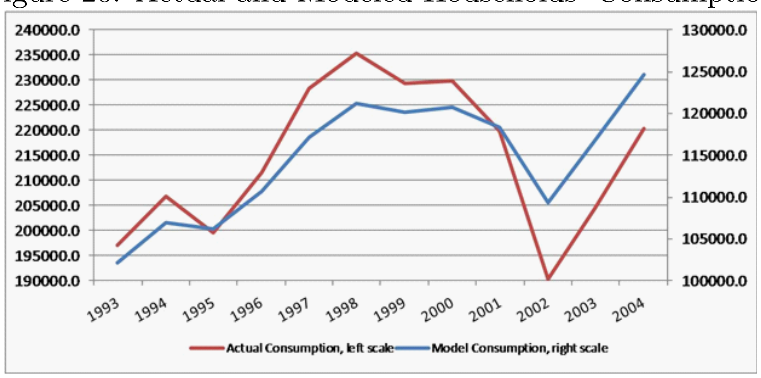


Validation of Solow Model Period 1993-2004 All currencies in graphics are in millions of 1993 local currency.

Actual and Modeled Households' Consumption.

Contemporaneous Correlation coefficient +0.81

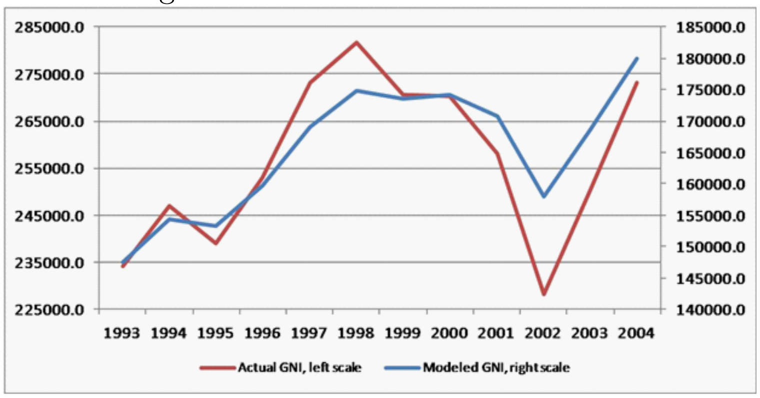
Figure 20: Actual and Modeled Households' Consumption



Actual and Modeled GNI

Contemporaneous Correlation coefficient + 0.87

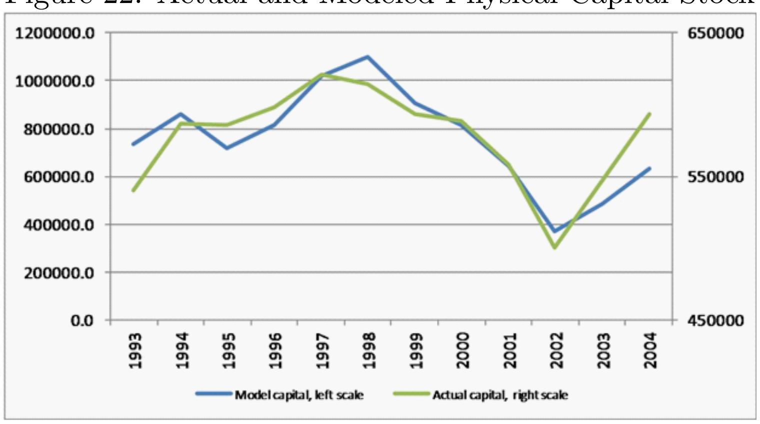
Figure 21: Actual and Modeled GNI



Actual and Modeled Physical Capital Stock.

Contemporaneous Correlation coefficient +0.86

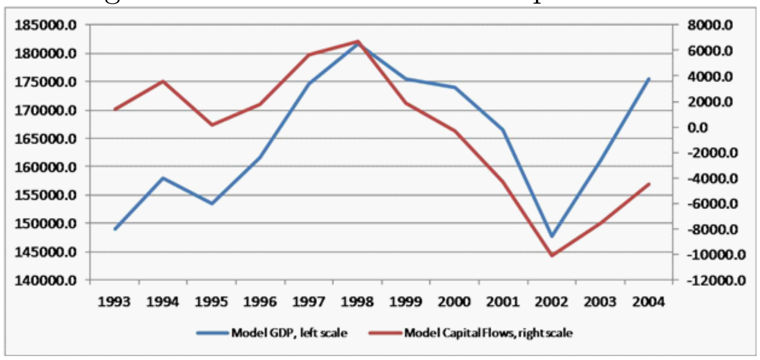
Figure 22: Actual and Modeled Physical Capital Stock



Modeled GDP versus Modeled Capital Flows that are in a pro-cycle relationship.

Contemporaneous correlation coefficient +0.70.

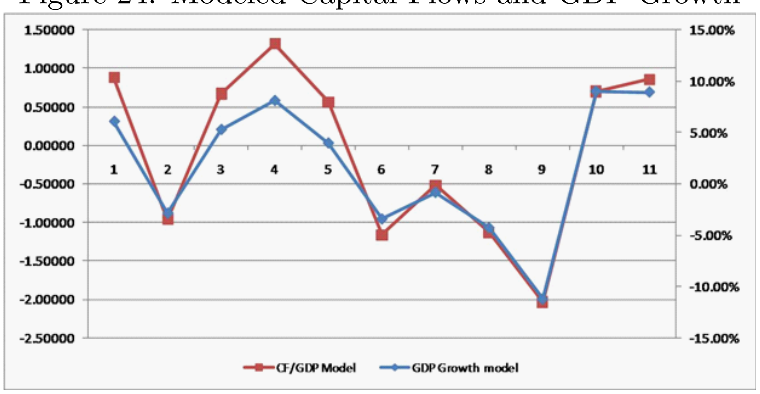
Figure 23: Modeled GDP and Capital Flows



Modeled Capital flows and Modeled GDP growth levels.

All currencies in graphics are in millions of 1993 local currency. It shows that the impact of the 1995 capital outflow shock originated by the Mexican crisis did not significantly affect the GDP growth as subsequent capital shock did.

Figure 24: Modeled Capital Flows and GDP Growth

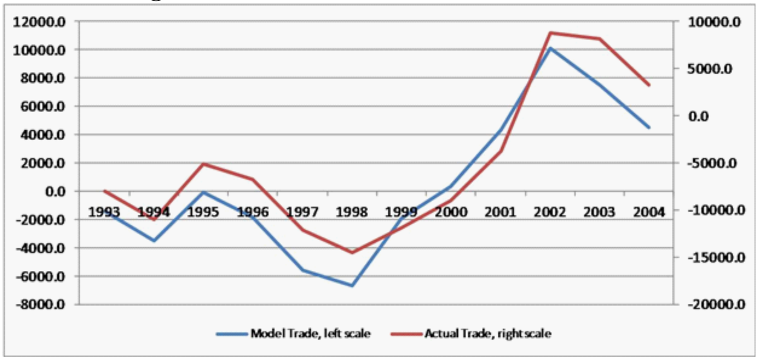


Modeled CF/GDP righ scale, Modeled GDP Growth left scale

Actual and Model Trade Account.

Contemporaneous correlation coefficient +0.95

Figure 25: Actual and Modeled Trade



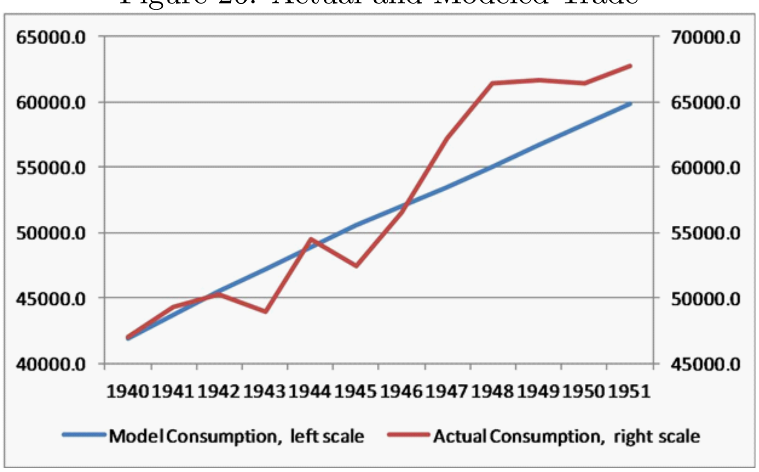
9.4.2 Validation Ramsey Models

Validation Ramsey 1940-1951 All currencies in graphics are in millions of 1993 local currency.

Actual and Modeled Households' Consumption.

Contemporaneous correlation coefficient: +0.96

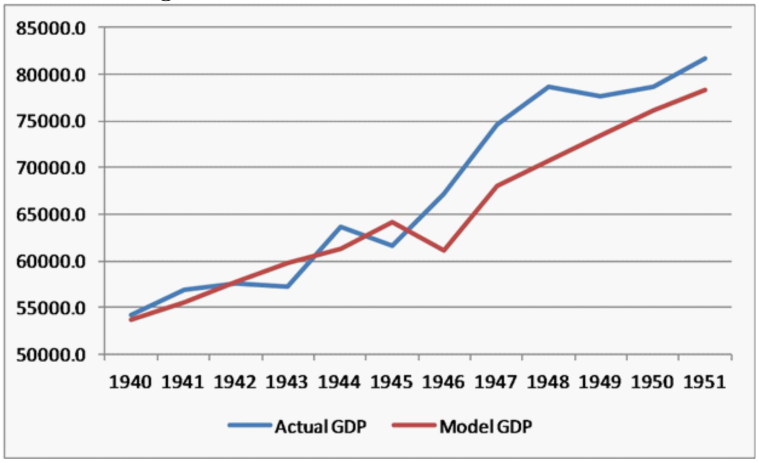
Figure 26: Actual and Modeled Trade



Actual and Modeled GDP.

Contemporaneous correlation coefficient : +0.91

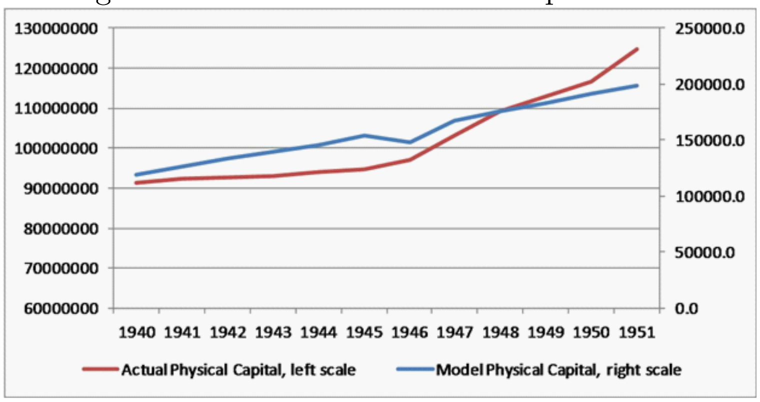
Figure 27: Actual and Modeled GNI



Actual and the modeled physical capital stock.

Contemporaneous correlation coefficient: +0.91

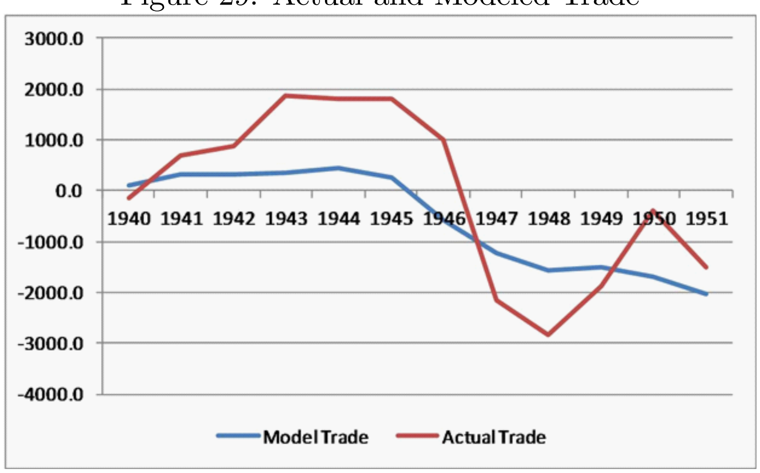
Figure 28: Actual and Modeled Capital Stock



Actual and Model Trade. A trade reversal in year 1946.is shown.

Contemporaneous correlation coefficient: +0.84

Figure 29: Actual and Modeled Trade



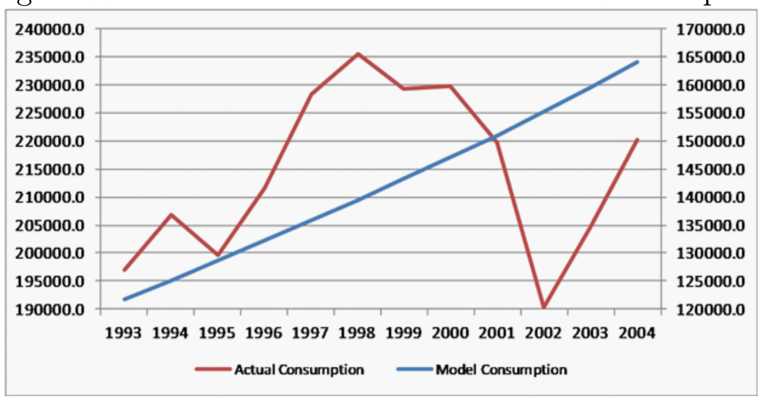
Validation Ramsey 1993-2004 All currencies in graphics are in millions of 1993 local currency.

Actual and Modeled Households' Consumption.

Contemporaneous correlation coefficient: +0.18

See below comparison of actual data and Solow and Ramsey consumption.

Figure 30: Actual and Modeled Households Consumption

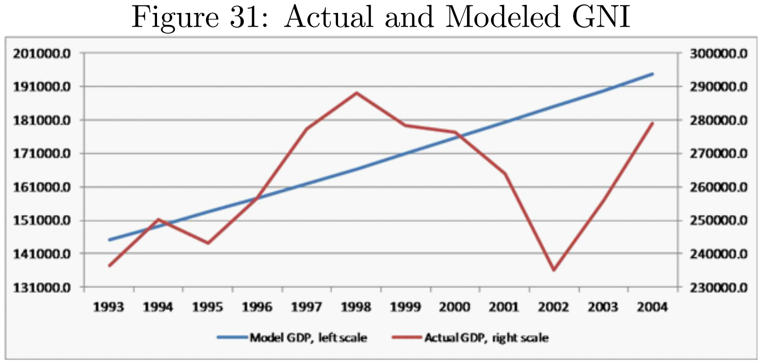


Actual Consumption left scale, Modeled Consumption right scale.

Actual and Modeled GDP

Contemporaneous correlation coefficient: +0.12

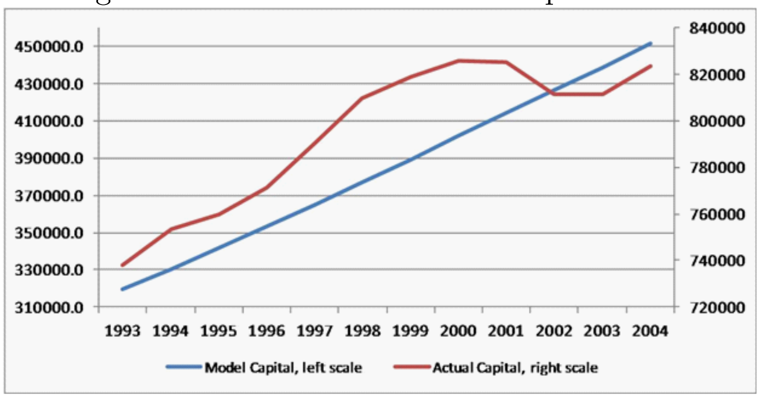
Figure 31: Actual and Modeled GNI



Actual and Modeled Physical Capital Stock

Contemporaneous correlation coefficient: +0.85

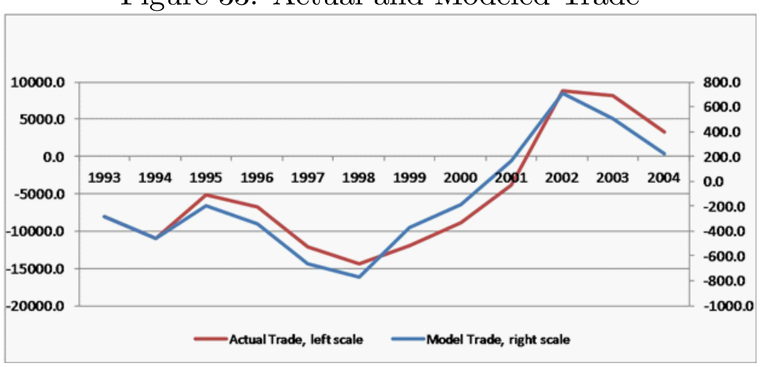
Figure 32: Actual and Modeled Capital Stock



Actual and Model Trade.

Contemporaneous correlation coefficient: +0.96

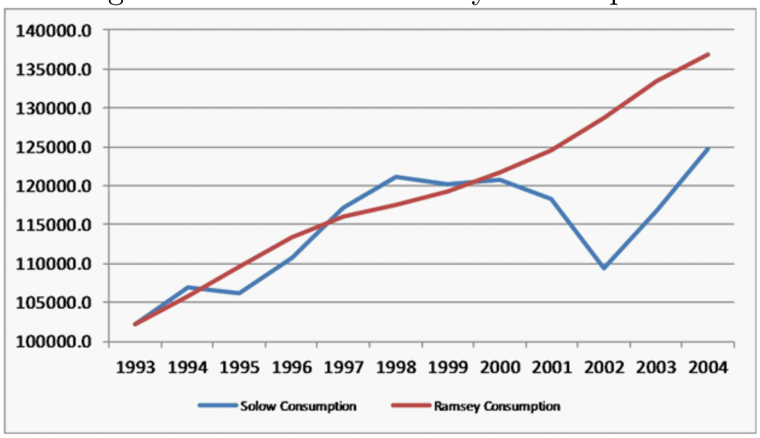
Figure 33: Actual and Modeled Trade



Comparison of Solow Consumption and Ramsey Consumption. Period 1993-2004

Capital inflows start to reduce in year 1998 and there was a sizable, sudden stop of capital inflows in year 2001 that Euler equation path cannot follow the actual data (and the Solow consumption) trend until year 2002.

Figure 34: Solow and Ramsey Consumption



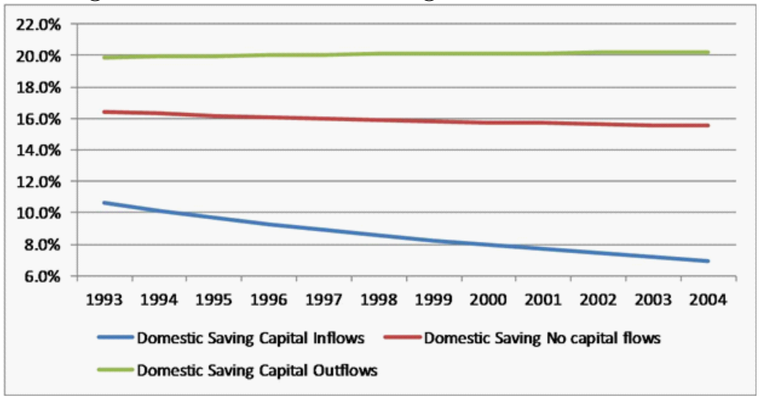
After year 2002, Euler equation path follows the Solow consumption trend.

9.5 Chapter 6 Model Simulations

9.5.1 Domestic Saving Impact for three scenarios

Domestic Saving for three scenarios, capital inflows, capital outflows and no-flows.

Figure 35: Domestic Saving for three Scenarios



9.5.2 Policy Experiment: Larger Saving Rate

Gross Domestic Product paths at 30% and 60% domestic Rate

Figure 36: Larger Saving Rate