Sovereign Debt and Tax Collection Dynamics in Argentina

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SOVEREIGN DEBT AND TAX COLLECTION DYNAMICS IN ARGENTINA

by

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A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

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Abstract

SOVEREIGN DEBT AND TAX COLLECTION DYNAMICS IN ARGENTINA

by

Kyle R. Bauser

Advisor: Professor Merih Uctum

This manuscript examines how the dynamic macroeconomic effects from shocks to taxes and inflation differ between the United States and Argentina. On the fiscal side, wages, private capital, and consumption tax cuts have long-run revenue growth effects (in both countries) that mitigate initial tax receipt losses. These growth effects, however, are larger in Argentina – a country where both the consumption tax rate and sensitivity to wage changes are higher. Specifically, Chapter 2 finds that growth from a U.S. capital tax cut pays for roughly 60% of the initial static loss, whereas the corresponding effect in Argentina is 80%. On the monetary side, multiple regimes are then considered with money in the utility function to determine optimal scenarios, holding tax revenues constant. Chapter 3 concludes that distortions from taxes on wages, private capital, and inflation outweigh the efficiency losses from a consumption tax, and as such, an economy whose government places more emphasis on consumption to generate tax receipts achieves higher utility. The tax frameworks introduced in Chapters 2 and 3 build from the neoclassical Ramsey growth models. Inflation’s role as a source of revenue via seigniorage in Chapter 3 is extended to the Argentine fixed income market in Chapter 4. Using proprietary pricing data and a structural vector autoregression framework, Chapter 4 finds that inflation as a predictor of the probability of default in Argentina is much
larger than the government claims it to be; despite non-investment-grade government bonds, Argentina’s fixed income market actually became more attractive during the U.S. mortgage crisis; and global risk aversion has predictive power in explaining sovereign spreads.
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# TABLE OF CONTENTS

Abstract...........................................................................................................................................iv  
Acknowledgements.......................................................................................................................vi  
Table of Contents.........................................................................................................................vii  
List of Tables....................................................................................................................................x  
List of Figures...............................................................................................................................xi

## Chapter 1

1 Introduction.................................................................................................................................1

## Chapter 2

2 Dynamic Scoring and the Consumption (Fair)Tax.................................................................4  
   2.1 Model...................................................................................................................................8  
      2.1.1 Production Function.................................................................................................8  
      2.1.2 Government.............................................................................................................9  
      2.1.3 Households.............................................................................................................10  
      2.1.4 Steady State............................................................................................................12  
   2.2 Dynamic Scoring..............................................................................................................14  
   2.3 Laffer Curves..................................................................................................................23  
   2.4 Transitional Dynamics.................................................................................................30  
   2.5 “Fair Tax”......................................................................................................................37  
      2.5.1 Consumption Tax Rate..........................................................................................38
2.5.2 Feedback Effect.................................................................39
2.6 Conclusion........................................................................40
A Steady State “Dot” Equations.................................................42
B Transitional Dynamics Derivations...........................................44
C Parameter Values................................................................46

Chapter 3
3 Tax Regime Optimality with Money in Utility.................................47
3.1 Model..................................................................................47
3.1.1 Production Function..........................................................48
3.1.2 Government......................................................................48
3.1.3 Households......................................................................49
3.1.4 Steady State.................................................................50
3.2 Revenue Effects with Seigniorage.............................................51
3.3 Optimal Utility.....................................................................54
3.4 Conclusion...........................................................................68
D Steady State “Dot” Equations..................................................70
E Parameter Values...................................................................73

Chapter 4
4 Argentine Debt Spreads: An Analysis with Global Risk Aversion and Inflation.........74
4.1 Review of the Literature........................................................75
4.2 Methodology........................................................................82
4.3 Data.....................................................................................................................85
4.4 Results..................................................................................................................88
4.5 Conclusion...........................................................................................................104

Chapter 5
5 Conclusion.............................................................................................................106

Bibliography.............................................................................................................107
LIST OF TABLES

Chapter 2

Table 1: U.S. and Argentine Feedback Effects and Implied Growth…………….18
Table 2: MW, Bauser, and Ferede Feedback Effects……………………………...19
Table 3: U.S. Feedback Effects along the Transition Path .............................34
Table 4: Argentine Feedback Effects along the Transition Path………………..34
Table 5: Parameter Descriptions and Values........................................46

Chapter 3

Table 6: U.S. and Argentine Feedback Effects and Implied Growth…………….52
Table 7: Parameter Descriptions and Values........................................73

Chapter 4

Table 8: Variables and Data Sources..................................................86
Table 9: Summary Statistics..............................................................88
Table 10: Regression Results............................................................89
LIST OF FIGURES

Chapter 2

Figure 1: Sensitivity of U.S. Feedback Effects to the Elasticity of Capital…………….19
Figure 2: Sensitivity of U.S. Feedback Effects to the Elasticity of Labor Supply………20
Figure 3: Sensitivity of Argentine Feedback Effects to the Elasticity of Capital………21
Figure 4: Sensitivity of Argentine Feedback Effects to the Elasticity of Labor Supply..22
Figure 5: U.S. Laffer Curves (Sensitivity to the Elasticity of Capital)………………….24
Figure 6: U.S. Laffer Curves (Sensitivity to the Elasticity of Labor Supply)………….25
Figure 7: Argentine Laffer Curves (Sensitivity to the Elasticity of Capital)……………26
Figure 8: Argentine Laffer Curves (Sensitivity to the Elasticity of Labor Supply)…….27
Figure 9: U.S. Feedback Effects Through Time……………………………………….35
Figure 10: Argentine Feedback Effects Through Time……………………………….36

Chapter 3

Figure 11: Sensitivity of U.S. Feedback Effects to Real Money Elasticity of Utility…53
Figure 12: Seigniorage Laffer Curve…………………………………………………….54
Figure 13: Optimal Tax Allocations…………………………………………………….61
Figure 14: Capital and Labor Tax Laffer Curves……………………………………….62

Chapter 4

Figure 15: Argentine Inflation (%/y) ……………………………………………………..87
Figure 16: Argentine Inflation (%/m) ……………………………………………………..87
Figure 17: Economic Activity IRF ................................................................. 90
Figure 18: Inflation IRF ................................................................. 92
Figure 19: Global Risk Aversion IRF ................................................................. 93
Figure 20: Sovereign Debt Spread IRF ................................................................. 94
Figure 21: Default Probability IRF ................................................................. 95
Figure 22: Economic Activity IRF – Pre and During Crisis ................................................................. 96
Figure 23: Default Probability IRF – Pre and During Crisis ................................................................. 97
Figure 24: Risk-Free Interest Rate IRF – Pre and During Crisis ................................................................. 98
Figure 25: Sovereign Spread IRF – Pre and During Crisis ................................................................. 99
Figure 26: Global Risk Aversion IRF – Pre and During Crisis ................................................................. 100
Figure 27: Inflation IRF – Pre and During Crisis ................................................................. 101
Figure 28: Cumulative Impulse Response Functions ................................................................. 103
1

Introduction

To what extent do tax cuts pay for themselves? Are the macroeconomic growth effects of tax changes significantly different in countries with heightened inflation, labor elasticity of supply, and consumption tax rates? Is it more optimal to favor one tax over another? Does inflation play a significant role when constructing tax policy and sovereign debt products in growing economies? The well-reasoned and correct answers to these questions are critical for the proper implementation of governmental fiscal and monetary policy – especially in emerging markets that rely heavily on global investors to drive growth. Accordingly: Chapter 2, “Dynamic Scoring and the Consumption (Fair)Tax”; Chapter 3, “Tax Regime Optimality with Money in Utility”; and Chapter 4, “Argentine Debt Spreads: An Analysis with Global Risk Aversion and Inflation” present conceptual frameworks and statistical models designed to study, test, and answer the above inquiries.

Chapter 2 is an extension of the Ramsey neoclassical economic growth model by including consumption taxes in the government revenue function and estimating the dynamic scoring revenue effects of tax cuts. This framework is applied to the U.S. and Argentina – two countries where consumers are faced with differing consumption taxes and respond differently to changes in wages. While static scoring significantly overestimates initial revenue losses from tax cuts in the U.S. and Argentina, the long-run growth effects of labor income and consumption tax cuts are more than two times greater in Argentina. Moreover, the model is modified to simulate a tax regime that only derives revenue from consumption – also known as a FairTax system. If such a system were to be
implemented, the tax rate required to generate the same level of receipts (as a fraction of output) is estimated to be 33.4% for the U.S. and 48.9% for Argentina.

Chapter 3 introduces inflation into the model and demonstrates that, while a FairTax regime is politically unfavorable and an unlikely scenario (especially in countries such as Argentina which already have high consumption taxes), a consumption tax by itself yields the highest utility. Labor tax distortions derived from reduced production; deadweight losses of saving reductions and investment inefficiencies stemming from private capital taxes; and inflation tax efficiency losses such as currency devaluation, high administrative costs, and suboptimal cash good-credit good decisions, outweigh the distortions from a consumption tax. Investment in capital stock, consumption, and output all drop proportionally more when labor, capital, and inflation taxes are the main sources of government revenue, thereby reducing utility (particularly when capital taxes are heightened). For example, under constant revenue levels, utility is 15.5% higher when capital, labor, consumption, and inflation taxes rates are 6.4%, 25.0%, 15.0%, and 3.0% as opposed to 25.0%, 25.0%, 5.0%, and 3.0%, respectively.

The overly optimistic ‘official’ inflation rate in Argentina has long been criticized (and widely disregarded) by Argentines and economists alike. The Instituto Nacional de Estadística y Censos (or National Institute of Statistics and Census) claims inflation is roughly 9% year over year; however, consultancies calculate it to be closer to 26% annually. The staggering 1700 basis point difference is quite worrisome if policy decisions are based on faulty statistics, especially when there is uncertainty on how long an economy like Argentina can sustain such inflation. Institutional investors, both domestic and abroad, are well aware of the discrepancy and must take the appropriate
risk precautions before purchasing fixed income and equity assets denominated in Argentine pesos. Chapter 4 therefore provides an extensive literature review of fundamental and external factors that affect Argentine sovereign debt spreads while confirming in an SVAR model the negative relationship between Argentine sovereign spreads and interest rates, the positive relationship of spreads and global risk aversion, and the positive correlation between probability of default and inflation.
Dynamic Scoring and the Consumption (Fair)Tax

The extent to which tax cuts pay for themselves is a question of major importance to institutions such as the Congressional Budget Office (CBO) and the Joint Committee on Taxation (JCT) when advising on fiscal policy. Traditional methods used by such consultancies estimate revenue changes (“the score”) of a tax proposal assuming certain macroeconomic aggregates such as the Gross National Product (GNP) growth rate, the rate of inflation, interest rates, and the unemployment rate are fixed (JCT, 2011). This long-standing method, traditionally called “static scoring,” of assuming a tax proposal does not change the total income growth rate – also observed by the CBO and the Office of Tax Analysis of the Department of Treasury – allows for easy comparison between the current “baseline” revenue estimates (with the same economic assumptions) and the anticipated receipts from a newly-proposed legislation. Baseline revenue estimates (provided to the JCT by the CBO every January) are 10-year projections of federal receipts and act as a starting point for the JCT when advising on new policy.

The fixed macroeconomic assumptions also allow for modeling of microeconomic behavior without having to predict future monetary and fiscal policy. Static scoring is the JCT’s traditional name for “conventional revenue estimates,” and can be misleading since behavioral responses are factored into the projections, so long as the GNP growth rate remains unaffected. Some examples of behavioral responses include an investor’s decision to realize capital gains as a result of lower taxes, or a laborer taking more of their taxable wages and less compensation in the form of fringe benefits in the
current period prior to a future tax increase. The JCT’s static models are designed with collaboration between economists, tax lawyers, and accountants, using algorithms and statistical packages with thousands of historical individual, corporate, estate, excise, and energy tax filings, to name a few.

While static scoring estimates are necessary starting points, “dynamic scoring,” on the other hand, has become an important tool to predict revenue fluctuations, as it considers feedback effects via changes in the aforementioned aggregate macroeconomic variables (i.e., the output growth rate and labor supply). In addition to providing, most notably, congressional members with the score of a proposed tax change, the JCT also provides dynamic estimates (also known as “macroeconomic modeling”) using various models. In many cases, the macroeconomic effects are so small that a brief statement in the proposal request is sufficient. However, in more detailed cases the JCT can utilize one of their three in-house models. They include macroeconomic equilibrium growth (“MEG”) models, overlapping generations (“OLG”) models, or dynamic stochastic general equilibrium (“DSGE”) growth models with infinitely lived agents. Additionally, the JCT utilizes the econometric models of Macroeconomic Advisors and HIS Global Insight.

The dynamic scoring framework is ideally suited to calculate macroeconomic feedback effects from a tax cut by comparing steady state levels under a conventional static system with those of a dynamic system. For example, if the dynamic score of a tax cut is 40% of the static effect, then 60% of the tax cut pays for itself through heightened consumption and investment activities. Often times dynamic scoring indicates that tax cuts partially pay for themselves; however, in special cases (such as countries like
Argentina with high consumption tax rates and elasticity of labor supply) tax cuts can be self-financing in the steady state.

This chapter follows the methods of Mankiw and Weinzierl (2006) (hereinafter MW) whereby baseline, static, and dynamic estimates are determined within a neoclassical Ramsey growth model. The baseline estimates are determined from initial model conditions (without any tax shock). Static revenue estimates are found by keeping the output growth rate constant after a tax change and are proportional to the tax change itself. The dynamic estimates are then calculated after considering all macroeconomic effects from a tax cut – essentially comparing the initial steady state with the new steady state.

Additionally, this chapter is an enhancement to the dynamic scoring literature (MW; Leeper and Yang, 2008; Ferede, 2008; Stinespring, 2010; and Strulik and Trimborn, 2011) by adding a consumption tax to the government revenue function (the MW model only considers a capital and labor tax), examining how the feedback effects differ when considering three taxes instead of solely taxes on labor and capital, and exploring the differences in macroeconomic growth between the United States (as a benchmark) and Argentina (a country with different labor supply responses to wage fluctuations and a high consumption tax rate).

The results of this augmentation demonstrate that when accounting for a consumption tax, growth pays for 61% of the static revenue loss of a capital tax cut and 20% of a labor tax cut. These growth effects are larger than the 53% and 17% found by MW. When the same methodology is applied to the Argentine economy, the growth effects are 82% and 48% – the respective differences being mainly attributable to the
significant feedback effects of extra after-tax wages and private capital. The growth effects from a consumption tax cut for the U.S. and Argentina are 10% and 24%, respectively.

Section 2.3 derives Laffer curves for each tax rate. The revenue-maximizing capital and labor tax rates are 44.3% and 70.2%, and 34.9% for the U.S. and 49.6% for Argentina, respectively. Visual aids are then used to show the sensitivity of the Laffer curves to the elasticities of labor and capital. An additional consideration to the dynamic scoring outcomes is the time period in which each effect takes place. For example, the efficacy of tax policy advocating for lower taxes might be called into question if the steady state growth effects do not materialize until many years after the tax cut. The reduction in revenue following a labor tax cut is likely the result of the substitution effect being larger than the income effect as consumers decide to increase their leisure time after an increase in after-tax wages. However in the longer term, consumer behavior changes and hours worked increases significantly. Section 2.4 therefore examines the transitional dynamics of tax cuts, and finds that the immediate impact of a capital, labor, and consumption tax cut in the U.S. is 4.3%, 13.4%, and 7.0%, respectively.

Section 2.5 modifies the dynamic scoring framework to simulate a “FairTax” system whereby the government only collects receipts from a single, flat-rate consumption tax. While the probability of the U.S. or Argentina switching to a FairTax system is low, the appropriate tax rate that would be required for each country to replace their current systems is the subject of considerable debate. Tuerck et al (2007) suggest that a tax-exclusive rate of 30% (or a 23% tax-inclusive rate) would be sufficient to
generate similar revenue levels as under the conventional U.S. tax structure.\(^1\) Similarly, Section 2.5 finds that a tax-exclusive consumption rate of 33.4% (or a tax-inclusive rate of 25.0%) would generate the same revenue in the conventional tax system.\(^2\) In Argentina, the value is 48.9% (or a tax-inclusive rate of 32.8%).\(^3\) Dynamic scoring of the FairTax model finds that a consumption tax cut pays for 8.3% of the static effect in the long run in the U.S. and 19.7% in Argentina.

### 2.1 Model

In this section, the Ramsey growth model is augmented to include a tax-collection scheme based on private capital, labor, and consumption. The model assumes an infinitely-lived representative household that chooses consumption, \(C\), private capital, \(K\), and hours worked, \(N\), to maximize expected utility; profit-maximizing firms; labor supply that is elastic; and a government that balances its budget via government transfers, \(g_T\).

#### 2.1.1 Production Function

The production function has constant returns to scale in competitive input and output markets. The function, suggested by Barro and Sala-i-Martin (2004), in per efficiency unit terms is\(^4\)

\[
y = f(k, n) = k^a n^{1-a}. \tag{1}
\]

\(^1\)This rate is suggested in H.R. 25, Fair Tax Act of 2007.
\(^2\)The tax-inclusive rate means that a tax on a good priced at $86.4 would be $13.6 (or 13.6%), bringing the total price to $100. The tax-exclusive rate would be 15.7% (or 13.6/86.4), or equal to \([\text{tax inclusive rate} / (1-\text{tax-inclusive rate})]\).
\(^3\)Throughout this paper, \(t_e\) will denote the tax-exclusive consumption rate.
\(^4\)Each variable is adjusted to per efficiency unit (or per effective worker), which is calculated by dividing by \(AN\). \(A\) represents labor-augmenting technology with a growth rate equal to \(g\). In other words, \(A = A_0 e^{gt}\).
The production function is twice continuously differentiable on the set of positive real numbers, \( R^2_{i,n} \), and satisfies the **Inada conditions**: \( f_i \to \infty \) as \( i \) approaches zero and \( f_i \to 0 \) as \( i \) approaches infinity, where \( i = k \) and \( n \).

Per capita output, \( y \), is produced by households in the form of per-efficiency unit labor, \( n \), and private capital, \( k \). Profit-maximizing firms produce until their input costs equal their corresponding marginal products, which are given as:

\[
\begin{align*}
    r &= f_k(k, n) = \alpha k^{\alpha-1} n^{1-\alpha}, \\
    w &= f_n(k, n) = (1 - \alpha) k^{\alpha} n^{-\alpha}.
\end{align*}
\]

The variable \( r \) is the before-tax rate of return on capital and \( w \) is the wage rate.

### 2.1.2 Government

This paper assumes tax revenues collected by the government come from return on private capital, \( rk \), and wages, \( wn \), as in MW. However, a tax, \( t_c \), on per-effective consumption, \( c \), is added to the revenue function.\(^5\) As in MW, the government maintains a balanced budget by spending tax receipts, \( R \), on government transfers, \( g_T \).\(^6\) The government budget constraint can therefore be defined in per-effective worker terms as:

\[
    R = g_T = t_n wn + t_k nk + t_c c, \quad \text{MW Model (4a)}
\]

where \( t_n \) and \( t_k \) are taxes on labor and private capital, respectively. Government transfers can take the form of activities such as welfare, farm subsidies, social security, and unemployment benefits.

---

\(^5\)Per-capita, per-effective, and per-efficiency are used synonymously throughout the paper.

\(^6\)For a discussion on how the results change under different government financing schemes see Section 2.2.
2.1.3 Households

The representative household is assumed to be infinitely-lived and derives utility from consumption and disutility from working. The utility function takes the form proposed by King et al (1988) whereby preferences are characterized by consumption and labor. The household’s utility function is given as:

\[ U = \int_{0}^{\infty} e^{-\rho t} \frac{(ce^{\theta t})^{1-\gamma}e^{(1-\gamma)v(n)-1}}{1-\gamma} dt, \]  

where \( \gamma \) is the curvature parameter, \( \rho \) is the discount rate of the consumer’s time preferences, \( g \) is the rate of labor-augmenting technological change, and \( v(n) \) is a differentiable function of labor supply.

The supply function, \( v(n) \), is defined in Barro and Sala-i-Martin (2004) as:

\[ v(n) = \frac{1+\sigma}{\xi n^\sigma}, \]  

where \( \xi \) is a scalar set equal to 3, as is the case in business cycle literature – labor time is restricted to about 1/3 of the total time available. The constant \( \sigma \) (greater than zero) is the constant-consumption elasticity of labor.\(^7\)

The elasticity of labor supply, or the responsiveness of labor supply to wage changes, has an important role in determining the impact of the feedback effect. The empirical value of \( \sigma \) varies widely in the literature. For example Fuchs, Krueger, and Poterba (1998) found in a survey that the median labor economist believes the value is 0.18 for men and 0.43 for women. Kimball and Shapiro (2003) find that the Frisch (constant marginal utility) and constant-consumption elasticities are near one and roughly 1.25, respectively. Peterman (2012) finds that microeconomists estimate the Frisch labor

\(^7\)The results do not change when \( \xi \) fluctuates. For example, when \( \xi = \frac{1}{3} \) the dynamic feedback effect (explained later) for a change in the labor tax decreases by \( 3\times10^{-14} \). The same is true for values higher than one and for changes in the other taxes.
supply elasticity to be between zero and one half, while macroeconomists tend to use values between two and four when calibrating their general equilibrium models. Reynaga and Rendon (2012) assert the Peruvian Frisch elasticity to be 0.38, while González and Sala (2011) find Brazilian, Uruguayan, Paraguayan, and Argentine values to be -1.9, -1.4, -13.1, and 12.8, respectively. The 12.8 for Argentina is highly unlikely and too far from consensus estimates that an average instead will be used for the calibration in the next section. Shimer (2010) uses four different values of elasticities in his calculation of measuring the wedge between the marginal rate of substitution of consumption for leisure and the marginal product of labor (i.e. the labor wedge); he considers $\sigma$ equal to 0.5, 1, 4, and $\infty$ (perfectly elastic). Buffie et al (2012) and Prescott (2004) assert that an elasticity of 3 is appropriate for international developing economies abroad. Reichling and Whalen (2012) purport that macro estimate range from 2 to 4. Finally, Ribeiro (2001) calculates 0.01 to be appropriate for Brazil.

When $\sigma$ is equal to zero, the labor supply curve is perfectly inelastic, which implies hours worked are insensitive to fluctuations in wages. This chapter uses MW’s constant-consumption value of 0.5 when calibrating to the U.S. economy and 1.5, which is based on an average of international and Latin American estimates, for the calibration of Argentina. Given the amount of lower-skilled demand and labor force in Argentina, we would naturally expect the labor supply to be more elastic than the United States’ elasticity. It should be noted that there is a difference (though slight, according to Kimball and Shapiro) between the Frisch and constant-consumption elasticities. For reference, Bilbiie, 2009 and Kimball and Shapiro both outline that the Frisch value is always below the constant-consumption elasticity.
In order to pay for consumption, consumption taxes, and investment in private capital, \( i_k \), households are faced with a budget constraint consistent with fiscal structure. Household disposable income is derived from after-tax wages, \((1 - t_n)wn\), after-tax return on private capital, \((1 - t_k)rk\), and government transfers:

\[
(1 - t_k)rk + (1 - t_n)wn + g_T = (1 + t_c)c + i_k. \tag{7}
\]

Investment in capital, \( i_k \), is equal to the change in capital, \( \dot{k} \), plus existing capital adjusted for the growth rate, \( g \). This relationship is described as:

\[
i_k = \dot{k} + gk. \tag{8}
\]

The household’s dynamic budget constraint in per-effective worker terms is total wages, returns from private capital, and government transfers less consumption and private capital adjusted for technological change. In other words, combining Equations (7) and (8) gives the household budget constraint:

\[
\dot{k} = (1 - t_n)wn + (1 - t_k)rk + g_T - (1 + t_c)c - gk, \tag{9a}
\]

where \( \lim_{t \to \infty} ke^{-\rho t} = 0 \).

The steady state equilibrium is determined by the above conditions, as will be shown in the next subsection.

### 2.1.4 Steady State

Given the above utility preferences in Equation (5) subject to the budget constraint in Equation (9a), household maximization of a Hamiltonian framework with respect to \( c \) and \( n \) yields the following first-order conditions: \(^8\)

\[
v'(n) = \frac{(1-t_n)w}{(1+t_c)c'} \tag{10}
\]

\(^8\) For derivations of the Hamiltonian first-order conditions, see Appendix A.
which, after setting equal to the derivative of Equation (6) with respect to $n$, becomes

$$\frac{(1-t_n)w}{(1+t_c)c} = \frac{1+\sigma}{\sigma} \xi n^{\frac{1}{\sigma}},$$

(11a)

and

$$\frac{c}{\dot{c}} = \frac{1}{\gamma} [(1 - tk)r + (1 - \gamma)v'(n)\dot{n} - (\rho + gy)].$$

(12)

In the steady state all the “dot” variables become zero, which reduces the intertemporal first-order condition to

$$r = \frac{\rho + gy}{1-t_k}.$$  

(13a)

Moreover, the budget constraint in Equation (9a) becomes zero in the steady state making consumption equal to

$$c = \gamma - gk.$$  

(14)

The steady-state values of the endogenous variables, $k$, $n$, $r$, $w$, and $c$ are full determined by Equations (1), (2), (3), (11), (13a), and (14).

The above system of simultaneous equations can be solved with a mathematical software package such as Maple. Steady state labor, $n^{ss}$, private capital, $k^{ss}$, and consumption, $c^{ss}$, are as follows:

$$n^{ss} = \left[\frac{(1-t_n)(1-\alpha)(\rho + \gamma)}{\xi(1+t_c)(\rho + \gamma) - \alpha(1-t_k)}\right]^{\frac{1}{1+\sigma}},$$

(15)

$$k^{ss} = n^{ss} \left[\frac{(1-t_k)\alpha}{\rho + \gamma}\right]^{\frac{1}{1-\alpha}},$$

(16)

$$c^{ss} = n^{ss} \left[\frac{(1-t_k)\alpha}{\rho + \gamma}\right]^{\frac{1}{1-\alpha}} - g \left[\frac{(1-t_k)\alpha}{\rho + \gamma}\right]^{\frac{1}{1-\alpha}}.$$

(17)

---

9 Note that through simplification $wn + rk = \gamma$.  

13
The above steady-state variables can then be used to determine revenue in the steady state. The steady-state revenue function is necessary to derive the dynamic scoring feedback effects.

### 2.2 Dynamic Scoring

Unlike dynamic scoring, static scoring does not account for macroeconomic feedback effects such as changes in consumption, labor supply, investment and saving following a tax cut. The static effect of a capital, labor, and consumption tax cut is the derivative of Equation (4a) with respect to $t_k$, $t_n$, and $t_c$, respectively:

\[
\frac{dR}{dt_k}|_{\text{static}} = rk = \alpha y, \tag{18}
\]

\[
\frac{dR}{dt_n}|_{\text{static}} = wn = (1 - \alpha)y, \tag{19}
\]

\[
\frac{dR}{dt_c}|_{\text{static}} = c. \tag{20}
\]

The static effect of a tax cut therefore leads to a proportional decrease in tax revenues by its respective tax base. As is the case at the JCT, the output growth rate stays constant following a tax cut. Conveniently, we are able to write the static effects of capital and labor in terms of output, $y$. This paper asserts that in the static effect for consumption, the consumption tax base will stay constant. As such, the static score will be proportional to the tax base, as in the other two taxes.

Dynamic scoring, on the other hand, allows the endogenous variables to fluctuate following a tax change. Rather than taking the derivative of Equation (4a), as was the case for static scoring above, we will consider the new steady-state revenue function
where the steady-state values for private capital, labor, and consumption are described by Equations (15)-(17) derived above. The dynamic effects are calculated by taking the derivative of $R^{ss}$ with respect to each tax.\(^{10}\) The static effect is then pulled out of the dynamic effect to give the feedback effect. The following equation shows this relationship:

$$\frac{dR}{d(tax)}|_{dynamic} = [Feedback\ Effect] \cdot \frac{dR}{d(tax)}|_{static}.$$  

The feedback effect represents the percentage of the estimated static revenue decrease that is actually lost. In other words, if the feedback effect is 40\%, then 60\% of the estimated static revenue loss after a tax cut is mitigated via macroeconomic feedback effects such as increased labor supply, investment in capital, saving, and consumption. If the feedback is negative, then not only is the static revenue loss following a tax cut completely financed (or recovered), but macroeconomic feedback effects actually generate larger tax receipts than under the initial tax rate. Some economists would therefore argue that the economy exhibited tax rates that started on the right side of the Laffer curve apex. If the feedback effect is greater than one, however, then the initial static estimate underestimates the revenue loss of a tax cut.

Given Equation (21), the actual dynamic scoring estimates following a capital, labor, and consumption tax, respectively, are given as

\(^{10}\) Since parameter values are plugged into this equation, the only variable left is the corresponding tax rate. If this is done by hand (without entering parameter values), then the total derivative must be derived.
where $A = \left(\frac{\alpha(1-t_k)}{S}\right)^{1-\alpha}$ and $S = \rho + \gamma g$. The feedback effects have three terms, each of which are the capital-, labor-, and consumption-feedback effect from a tax cut. For example, the first term in Equation (24) is the capital-feedback effect from a consumption tax cut, while the second and third terms are labor- and consumption-feedback effects from a consumption tax cut, respectively.\footnote{Each term in Equations (22)-(24) is positive, which means the plus or minus sign in front of each term indicates whether the feedback effect is increased or decreased, respectively.} Numerical feedbacks are calculated by plugging in plausible parameter values suggested by MW and others, as seen in Table 5 of Appendix C. There is widespread debate about setting the appropriate rate for the U.S.
consumption tax. Suggested rates range from 5%, Trabandt and Uhlig (2009), to 28%,
Diamond and Zodrow (2008), depending on the tax collection structure. Given the tax
framework in this paper, $t_c = 0.05$. The VAT rate in Argentina is 0.21, which is what
this paper assumes as well.

MW find, for example, $\frac{dR}{dt_k} |_{\text{dynamic}} = 0.47 \cdot \frac{dR}{dt_k} |_{\text{static}}$ and $\frac{dR}{dt_n} |_{\text{dynamic}} = 0.83 \cdot \frac{dR}{dt_n} |_{\text{static}}$, which means growth pays for 53% of the static revenue loss from a capital tax cut and 17% from a labor tax cut. The dynamic feedback effects for the U.S. in this chapter are as follows:

$$\frac{dR}{dt_k} |_{\text{dynamic}} = 0.389 \cdot \frac{dR}{dt_k} |_{\text{static}},$$

$$\frac{dR}{dt_n} |_{\text{dynamic}} = 0.803 \cdot \frac{dR}{dt_n} |_{\text{static}},$$

$$\frac{dR}{dt_c} |_{\text{dynamic}} = 0.897 \cdot \frac{dR}{dt_c} |_{\text{static}}.$$

Growth pays for 61.1%, 19.7%, and 10.3% of a capital, labor, and consumption tax cut, respectively. The increased growth effects of the capital and labor tax cuts compared to the MW results are due to the additional avenue of tax collection added in this model – namely, consumption. In other words, tax receipt losses resulting from labor and capital tax cuts are now buffered by the addition of consumption tax revenue. As a result, tax receipts are not as dependent on labor and private capital in this model as they were in the MW model, which explains the higher growth effects. Additionally, the feedback effects for Argentina can be seen in Table 1 below.
As outlined earlier, this chapter assumes that all tax receipts are spent on government transfers. However, as would be expected, the feedback effects change as the government alters its allocation of receipts. For example, Ferede (2008) extends the MW paper by examining how the capital and labor feedback effects change when the government allocates tax receipts to 1) government transfers (as in this paper and MW), 2) government consumption, or 3) productive services.\textsuperscript{12} Table 2 below summarizes the results of Ferede, MW, and this paper. The results for each author have very similar labor feedback effects and somewhat similar capital effects under the transfer scheme.

\textsuperscript{12} Both MW and Ferede do not use a consumption tax in their model.

### Table 1

**U.S. and Argentine Feedback Effects and Implied Growth**

<table>
<thead>
<tr>
<th>Feedback Effects</th>
<th>US</th>
<th>AR</th>
</tr>
</thead>
<tbody>
<tr>
<td>tk</td>
<td>0.389</td>
<td>0.180</td>
</tr>
<tr>
<td>tn</td>
<td>0.803</td>
<td>0.524</td>
</tr>
<tr>
<td>tc</td>
<td>0.897</td>
<td>0.763</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Implied Growth Effects</th>
<th>US</th>
<th>AR</th>
</tr>
</thead>
<tbody>
<tr>
<td>tk</td>
<td>61.1%</td>
<td>82.0%</td>
</tr>
<tr>
<td>tn</td>
<td>19.7%</td>
<td>47.6%</td>
</tr>
<tr>
<td>tc</td>
<td>10.3%</td>
<td>23.7%</td>
</tr>
</tbody>
</table>
The feedback effects have some variability based on parameter values. As such, the sensitivity of the feedback effects to the elasticity of capital, $\alpha$, and labor, $\sigma$, can be seen in Figures 1 and 2 below, respectively.

**Figure 1**
Sensitivity of U.S. Feedback Effects to the Elasticity of Capital
Figure 2
Sensitivity of U.S. Feedback Effects to the Elasticity of Labor Supply
Figure 3
Sensitivity of Argentine Feedback Effects to the Elasticity of Capital

[Graph showing sensitivity of feedback effects to elasticity of capital]
From the figures above, capital feedback effects are sensitive to the elasticity of capital, while the labor tax feedback effect is sensitive to both the elasticity of capital and the elasticity of labor supply.
2.3 Laffer Curves

Graphing the steady-state revenue function, $R^\infty$, with respect to the corresponding tax rate, while holding everything else constant, yields the following Laffer Curves below for a capital, labor, and consumption tax, respectively. The revenue-maximizing capital tax rates for the U.S. and Argentina are 44.3% and 34.9%, respectively. The corresponding labor tax rates are 70.2% and 49.6% for the U.S. and Argentina. The increase in revenue, of course, is not an indication of higher economic surplus.
Figure 5
U.S. Laffer Curves
(Sensitivity to the Elasticity of Capital)
Figure 6
U.S. Laffer Curves
(Sensitivity to the Elasticity of Labor Supply)
Figure 7
Argentine Laffer Curves
(Sensitivity to the Elasticity of Capital)
The results above for each tax rate assume the other two are held constant. While this assumption is required to derive the Laffer curves, it is unlikely that one tax rate would be cut (or hiked) drastically without others changing as well. The analysis above could therefore be extended by examining how the Laffer curves change as the other tax rates vary as well. The flat (asymptotic) consumption tax curve above is similar to results found in Trabandt (2009). He shows that most of the time a consumption tax Laffer curve does not exist, and that income effect usually dominates the substitution effect. He does find, in one case, that when the isoelastic curvature for consumption parameter in the
utility function is less than one (or $\gamma < 1$), the substitution effect outweighs the income effect and a consumption tax Laffer curve exists. His model uses discrete time with a slightly different utility function than the one presented in this chapter.

The new dynamic public finance (NDPF) literature has some clear differences with the traditional Ramsey growth results. In particular, the NDPF model exploits skill sets of individuals by incentivizing them via social security. Since skills are private information, people have an incentive to report the truth and strive to produce more, as they will be eligible for larger transfers after retirement. Also, taxes on assets are determined by future labor income, and unlike the Ramsey model, capital tax rates of zero are suboptimal. The suboptimal finding stems from the need of a positive asset tax on current assets (or positive distortion on savings) so as to offset a reduced labor tax on current income (Golosov et al, 2007). In this example, the reduced income tax in the current period is the result of increased taxes on future labor, as it is more risky (a type of insurance against uncertainty). In other words, labor is taxed more in the future, which allows for lower taxes in the current period; in order to dissuade savings into the future, a positive capital tax is required (Grochulski and Kocherlakota, 2007).

As in NDPF work by Kocherlakota, recent work by Diamond and Saez (2011) find that taxing capital is optimal. They similarly find that there is positive utility in discouraging savings so as to promote labor supply when future wages are uncertain. Diamond et al (2011) also argue that taxes should be higher for top income earners (even more so than currently in the U.S.). The rational for this is that tax rates for low earners could be reduced as a result. Moreover, they purport the elasticity of labor supply for top earners is lower than what our current tax rates would justify. In other words, increased
taxes on the wealthy would not adversely affect labor supply or utility.

The overlapping generation (OLG) model differs from the Ramsey model in that horizons are finite, and agents overlap with another agent for at least one period. There are no bequests. The results of the traditional Ramsey growth model have several differences with the OLG model. It should be noted that in both models an increase in capital taxes reduces capital formation and reduces savings. A labor tax also reduces capital formation when labor supply is elastic. In the overlapping generations model (as opposed to the infinite horizon case), a portion of the consumption tax burden is shifted from labor to capital. In the infinitely-lived setting, consumption taxes minimally affect capital. An important difference in the two models is the generational turnover effect, which is the passing away of older, wealthier generations and replaced by new generation with zero wealth. Older generations that consume out of accumulated financial wealth are therefore hit harder by a consumption tax (Heijdra et al, 2000). As such, a consumption tax can become more burdensome when the wealthy generations, with a majority of the accumulated capital, bear most of the brunt of the tax.

This chapter, as in MW, assumes infinite horizons – assuming that generations are connected through altruistic bequests. To test the robustness, MW also extend their results to consider finite horizons. The results do not change when the model considers when a fraction of households consume their current income. This however only considers a government that collects taxes from labor and capital. MW also consider the framework proposed by Blanchard (1985) whereby households have the probability of dying off each period. If a household dies, it is replaced by another. Households therefore annuitize their wealth and bequests do not exist. If the probability of death each period is
zero the model is equivalent to an infinite horizons setup. MW find that if the probability of death is 0.02, correlating to a time horizon of fifty years, the capital tax growth effect falls from 50 to 45%. If the probability falls to 0.05 (or a life span of twenty years), the growth effect falls to 39%. While the results do change with assumptions regarding horizons, the changes are not extensive. These examples assume inelastic labor supply. Heijdra et al find that in the elastic case, a consumption tax has more of a negative effect on the older, wealthier generations, and allows capital stock in the long run to grow more via younger generation investment.

2.4 Transitional Dynamics

While the steady state feedback effects are an important indication of post-tax-cut behavior, they do not explain the whole story. If, for example, it takes twenty-five years for a tax cut to generate supply-side macroeconomic growth, then the efficacy of such a proposal will be called into question. It is essential to know at what point in time after a fiscal shock various factors come into play. Therefore, in this section the transitional time path of the revenue function after a tax cut will be mapped out following methods introduced in MW.

The transitional dynamics are derived from a system of log-linearized differential equations. We can derive the time path of tax revenues by finding the paths of the endogenous variables $k$, $n$, and $c$. Once we have found these time paths, we can insert them into the revenue function to see how revenue levels evolve over time. To calculate the paths, we need values of each variable at three points in time: before the tax cut (0), immediately after the tax cut ($\epsilon$), and in the steady state after the tax cut (ss). We will call
these variables $k_0, k_c, k^{ss}, n_0, n_c, n^{ss}, c_0, c_c$, and $c^{ss}$. We can solve for the initial and steady-state values by simply using the steady state equations derived above. We also know that the capital stock is temporarily fixed after a tax cut, meaning $k_0 = k_c$. We therefore must derive $n_c$ and $c_c$.

First-order household maximization of consumption and labor generate the following system of equations that represent economy dynamics.

\[
\frac{\dot{c}}{c} = \alpha (1 - tk)k^{\alpha-1}n^{1-\alpha} - (\rho + g),
\]

\[
\frac{\dot{n}}{n} = \frac{\alpha t k k^{\alpha-1} n^{1-\alpha} a_c}{\alpha + 1} + \rho + g (1 - \alpha),
\]

\[
\frac{\dot{k}}{k} = k^{\alpha-1} n^{1-\alpha} - \frac{c}{k} - g.
\]

These equations assume the utility function is logarithmic ($\gamma = 1$), which converts the original law of motion equation for consumption (12) to Equation (25).\(^{13}\)

These new dot equations are necessary because they can be easily linearized around the steady state:\(^{15}\)

\[
\frac{d\ln c}{dt} = \alpha (1 - tk)e^{(\alpha-1)(\ln k - \ln n)} - (\rho + g),
\]

\[
\frac{d\ln n}{dt} = \frac{1}{\alpha + 1} \left[ (\alpha t k e^{(\alpha-1)(\ln k - \ln n)} - \alpha e^{(\ln c - \ln k)} + \rho + g (1 - \alpha) \right],
\]

\[
\frac{d\ln k}{dt} = e^{(\alpha-1)(\ln k - \ln n)} - e^{(\ln c - \ln k)} - g.
\]

Equations (28)-(30) are then combined to solve for the steady state (ss).\(^{16}\)

\[
e^{(\alpha-1)(\ln k^{ss} - \ln n^{ss})} = \frac{\rho + g}{\alpha (1 - tk)}
\]

---

13MW assume the growth rate, $g$, is equal to zero
14The derivation of Equations (26) and (27) can be seen in Appendix B.
15Equations (28)-(30) are the same as (25)-(27) except the natural log is taken of the latter three, rearranged, and then exponentiated.
16Equations (28)-(30) are all set equal to zero, since in the long run the variables do not change with respect to time.
These two equations are then inserted back into Equations (28)-(30) and differentiated with respect to each logged variable. The first-order approximation around the steady state variables is characterized by the following system:

\[
\begin{bmatrix}
\frac{d\ln c}{dt} \\
\frac{d\ln n}{dt} \\
\frac{d\ln k}{dt}
\end{bmatrix} = \begin{bmatrix}
0 & -(\alpha - 1)(\rho + g) & (\alpha - 1)(\rho + g) \\
-(\rho + \zeta) & -(\alpha - 1)t_k(\rho + g) & \frac{(\alpha - 1)t_k(\rho + g) + (\rho + \zeta)}{\alpha(1-t_k)} \\
(\alpha + \frac{\rho}{\alpha})(1-t_k) & (\alpha + \frac{\rho}{\alpha})(1-t_k) & (\alpha + \frac{\rho}{\alpha})(1-t_k)
\end{bmatrix} \begin{bmatrix}
\ln c \\
\ln n \\
\ln k
\end{bmatrix},
\]

(31)

where \( \zeta = g(1 - \alpha(1 - t_k)) \). The mathematical software Matlab can be used to calculate the eigenvalues and eigenvectors of the matrix of parameters above. Assuming we call the three eigenvalues \( \phi, \omega, \) and \( \theta \), as well as the matrix of eigenvectors \( V \), we can define the paths of \( c_t, n_t, \) and \( k_t \) by

\[
\begin{align*}
\ln c_t &= \ln c^{ss} + v_{11}e^{\phi t}b_1 + v_{12}e^{\omega t}b_2 + v_{13}e^{\theta t}b_3, \\
\ln n_t &= \ln n^{ss} + v_{21}e^{\phi t}b_1 + v_{22}e^{\omega t}b_2 + v_{23}e^{\theta t}b_3, \\
\ln k_t &= \ln k^{ss} + v_{31}e^{\phi t}b_1 + v_{32}e^{\omega t}b_2 + v_{33}e^{\theta t}b_3,
\end{align*}
\]

Boundary conditions determine \( b_1, b_2, \) and \( b_3 \). Moreover, using parameter values specified in Table 5, we find that \( \phi > 0, \omega < 0 \) and \( \theta = 0 \). This implies that \( b_1 = 0 \) and \( b_3 = 0 \) because otherwise \( \lim_{t \to \infty} c_t \neq c^{ss} \). We therefore have

\[
\begin{align*}
\ln c_t &= \ln c^{ss} + v_{12}e^{\omega t}b_2, \\
\ln n_t &= \ln n^{ss} + v_{22}e^{\omega t}b_2, \\
\ln k_t &= \ln k^{ss} + v_{32}e^{\omega t}b_2.
\end{align*}
\]

\[\text{Footnotes:} \]

\[\phi = 0.182, \omega = -0.0994, \theta = 0.\]

\[v_{12} = -0.486, v_{22} = 0.0839, v_{32} = -0.869.\]
As previously mentioned, the capital stock stays temporarily fixed after a tax cut, meaning \( k_0 = k_e \):

\[
b_2 = \frac{(\ln k_0 - \ln k^{ss})}{v_{32}} = \frac{(\ln k_e - \ln k^{ss})}{v_{32}}, \tag{32}
\]

Using (32) we can define the dynamic system as

\[
\ln c_t = \ln c^{ss} + \frac{(\ln k_e - \ln k^{ss})}{v_{32}} v_{12} e^{\omega t}, \tag{33}
\]

\[
\ln n_t = \ln n^{ss} + \frac{(\ln k_e - \ln k^{ss})}{v_{32}} v_{22} e^{\omega t}, \tag{34}
\]

\[
\ln k_t = \ln k^{ss} + (\ln k_e - \ln k^{ss}) v_{32} e^{\omega t}. \tag{35}
\]

Equations (33)-(35) give us the log-values of each variable from immediately after a tax change until the steady state. The eigenvalue \( \omega \) describes the rates at which the variables converge to the steady state. Finally, since the revenue function is given as

\[
R_t = t_n w_t n_t + t_k r_t k_t + t_c c_t \\
= [(1 - \alpha)t_n + \alpha t_k] y_t + t_c c_t \\
= [(1 - \alpha)t_n + \alpha t_k] k_t^\alpha n_t^{1-\alpha} + t_c c_t, \tag{36}
\]

we are able to trace the revenue function through time following a tax change.

Table 3 below shows the percentage of the static loss mitigated by feedback effects following corresponding tax cuts for the United States and Table 4 shows the effects for Argentina. For a more visual representation, the following figures graph the effects over time after a tax cut.
Table 3
U.S. Feedback Effects Along the Transition Path

*Percentage of static revenue loss mitigated by economic growth*

<table>
<thead>
<tr>
<th>Time</th>
<th>Capital Tax Cut</th>
<th>Labor Tax Cut</th>
<th>Consumption Tax Cut</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Impact</td>
<td>4.3</td>
<td>13.4</td>
<td>7.0</td>
</tr>
<tr>
<td>1 Year</td>
<td>9.6</td>
<td>14.1</td>
<td>7.3</td>
</tr>
<tr>
<td>5 Years</td>
<td>26.5</td>
<td>15.9</td>
<td>8.2</td>
</tr>
<tr>
<td>10 Years</td>
<td>40.0</td>
<td>17.4</td>
<td>9.0</td>
</tr>
<tr>
<td>25 Years</td>
<td>56.3</td>
<td>19.1</td>
<td>9.9</td>
</tr>
<tr>
<td>50 Years</td>
<td>60.6</td>
<td>19.6</td>
<td>10.2</td>
</tr>
<tr>
<td>Steady-State Impact</td>
<td>61.1</td>
<td>19.7</td>
<td>10.3</td>
</tr>
</tbody>
</table>

Table 4
Argentine Feedback Effects Along the Transition Path

*Percentage of static revenue loss mitigated by economic growth*

<table>
<thead>
<tr>
<th>Time</th>
<th>Capital Tax Cut</th>
<th>Labor Tax Cut</th>
<th>Consumption Tax Cut</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Impact</td>
<td>1.3</td>
<td>7.1</td>
<td>0.0</td>
</tr>
<tr>
<td>1 Year</td>
<td>13.1</td>
<td>13.0</td>
<td>3.5</td>
</tr>
<tr>
<td>5 Years</td>
<td>45.4</td>
<td>29.2</td>
<td>12.9</td>
</tr>
<tr>
<td>10 Years</td>
<td>65.3</td>
<td>39.2</td>
<td>18.8</td>
</tr>
<tr>
<td>25 Years</td>
<td>80.4</td>
<td>46.7</td>
<td>23.2</td>
</tr>
<tr>
<td>50 Years</td>
<td>81.9</td>
<td>47.5</td>
<td>23.6</td>
</tr>
<tr>
<td>Steady-State Impact</td>
<td>82.0</td>
<td>47.6</td>
<td>23.7</td>
</tr>
</tbody>
</table>
Figure 9
U.S. Feedback Effects Through Time
Path Following a Capital Tax, Labor, and Consumption Tax Cut
Compared to the MW model, a capital tax cut results in a lower feedback initially but regains ground after the first year and evolves more quickly towards the steady state. The labor tax starts off higher and maintains this effect until the steady state. The small,
but not negligible, effect from a consumption tax cut mitigates 10.3% of the estimated static impact. The significant reduction in Argentine revenue following a labor tax cut is most likely the result of the income effect being smaller than the substitution effect – people decide to use the extra take-home income to relax and work less. In the longer term, however, consumer consumers choose to work more.

2.5 “FairTax”

This section proposes a tax system in which tax revenues are collected solely from a consumption tax – a proposal known by advocates as the “FairTax” system. There are numerous questions as to the feasibility and efficacy of such a tax system, many of which this chapter does not attempt to answer. However, the dynamic scoring framework introduced in previous sections caters nicely to answering two questions of interest regarding a FairTax system: What is a feasible consumption tax rate? and What are the macroeconomic implications following a consumption tax cut? In order to answer these two questions, it is necessary to augment the previous framework to model a FairTax.

Relatively small changes are required to model the proposed framework. For example, the revenue function in Equation (4a) becomes

\[ R = t_c c, \]  

(4b)

and the consumer budget constraint of Equation (9a) converts to

\[ \dot{k} = wn + rk + g_T - (1 + t_c)c - gk. \]  

(9b)

The first-order conditions via the Hamiltonian framework yields:\(^{19}\)

---

\(^{19}\) All of the derivations in this framework are nearly identical to those of the previous set up.
\[
v'(n) = \frac{-w}{(1+t_c)c},
\]
which setting equal to the derivative of Equation (6) with respect to \(n\) becomes
\[
-\frac{w}{(1+t_c)c} = -\frac{1+\sigma}{\sigma} \frac{1}{\xi n^{\sigma}},
\]
and
\[
\frac{\dot{c}}{c} = \frac{1}{\gamma} [r + (1 - \gamma)v'(n)\dot{n} - (\rho + \gamma)].
\]
The intertemporal first-order condition shown in Equation (13a) becomes
\[
r = \rho + \gamma y. \tag{13b}
\]
The steady-state endogenous variables \(y, k, n, r, w\) and \(c\) are therefore fully determined by Equations (1), (2), (3), (11b), (13b), and (14). The only equations that changed from before are (11b) and (13b). Steady-state labor, private capital, and consumption are as follows:
\[
n^{ss} = \left[\frac{(1-\alpha)(\rho + \gamma g)}{\xi(1+t_c)(\rho + \gamma g - \alpha g)}\right]^{\frac{\alpha}{1+\sigma}},
\]
\[
k^{ss} = n^{ss} \left[\frac{\alpha}{\rho + \gamma g}\right]^{\frac{1}{1-\alpha}},
\]
\[
c^{ss} = n^{ss} \left[\left(\frac{\alpha}{\rho + \gamma g}\right)^{\frac{\alpha}{1-\alpha}} - g \left(\frac{\alpha}{\rho + \gamma g}\right)^{\frac{1}{1-\alpha}}\right].
\]
Notice these steady-state variables are the same as their previous counterparts without \((1 - t_k)\) and \((1 - t_n)\).

### 2.5.1 Consumption Tax Rate

The steady-state consumption function, \(c^{ss}\), and the new revenue function in the steady state, \(R^{ss} = t_c c^{ss}\), allow us to answer the first question: What is a feasible
consumption tax rate? One way to answer this is by determining the consumption tax rate, \( t_c \), that generates the same ratio of revenues to output as the conventional tax system introduced in Section 2.1.

The revenue function introduced above is of the form

\[
R = t_n w_n + t_k r_k + t_c c.
\]

After solving the previous model and calculating numerical results, the consumption tax rate in the FairTax model can be calibrated to generate equal revenue to output levels. The consumption tax rate calculated is 33.4%. In other words, if the FairTax system were enacted in the U.S., a 33.4% tax-exclusive rate on consumption would be required for the government to collect the same amount of tax receipts as before the tax code change. It is not surprising that the corresponding required tax rate in Argentina (48.9%) is greater, given the much higher tax rate already present.

2.5.2 Feedback Effect

The macroeconomic growth factors of a consumption tax cut accounted for 10.3% of the static effect under the tax system introduced in previous sections – lower tax rates increase the labor, capital, and consumption tax bases. However, in this section, consumption is the only source of tax revenue growth following a tax cut. As a result, the numerical feedback effect is 91.7%, which means growth only mitigates 8.3% of the estimated static revenue loss. The corresponding equation is given as

\[
\frac{dR}{dt_c} \bigg|_{\text{dynamic}} = \left[ \frac{\gamma + (1+t_c)}{(1+\gamma)(1+t_c)} \right] \cdot \frac{dR}{dt_c} \bigg|_{\text{static}},
\]

which after inserting plausible parameter values becomes\(^{20}\)

\[ t_c \]

\(^{20}\) is now set equal to 0.334 and 0.489 for the U.S. and Argentina, respectively.
The growth effects in Argentina following a consumption tax cut are a bit higher, or 19.7%. In general, a lowered consumption tax does not have as many channels for feedback effects as in the previous model where the government collected revenues from other sources. This implies that tax cuts are less effective at stimulating growth and that the static estimate is more accurate under this simplified tax regime.

2.6 Conclusion

Conventional methods used by the CBO and JCT to estimate revenue losses following a tax cut involved static scoring. However, such methods do not consider long-run macroeconomic growth effects such as changes in the growth rates of output, labor supply, investment in private capital, saving, and consumption. Dynamic scoring, on the other hand, considers these feedbacks. In this chapter, the dynamic scoring framework introduced in Mankiw and Weinzierl (2006) is modified to incorporate a consumption tax in the revenue function and applied to the U.S. and Argentina. Revenue losses resulting from a private capital, labor, and consumption tax cut are statically overestimated by 61.1%, 19.7%, and 10.3% in the U.S. and 82.0%, 47.6%, and 23.7% in Argentina, respectively. The Laffer curve revenue-maximizing private capital and labor tax rates are 44.3% and 70.2% in the U.S. and 34.9% and 49.6% in Argentina. The conventional tax regime is further modified to model a FairTax scheme whereby the government only collects tax receipts from a flat-rate consumption tax. Under this system, a tax-exclusive
consumption tax rate of 33.4% (or 48.9%) is required to generate the same amount of revenue as the conventional tax system in the U.S. (or Argentina).
A  Steady-State “Dot” Equations

The steady-state dot equations are essential in solving the system for its endogenous variables. Given the utility function, (5), subject to the budget constraint, (9), the Hamiltonian set up is given as

\[ H = e^{-\rho t} \left( ce^{\beta t} \right)^{1-\gamma} e^{(1-\gamma)\nu(n)} - \lambda [(1-t_n)\omega + (1-t_k)\rho k + g_T - (1+t_c)c - g_k]. \]  \hspace{1cm} (A1)

First, the derivative of (A1) with respect to the control variable, \( c \), set equal to zero is given as

\[ e^{-\rho t} \left( ce^{\beta t} \right)^{1-\gamma} e^{(1-\gamma)\nu(n)} \frac{c - \nu(n)c - \gamma}{1 - \gamma} - \lambda (1 + t_c) = 0 \]

or

\[ \lambda = \frac{e^{-\rho t} \left( ce^{\beta t} \right)^{1-\gamma} e^{(1-\gamma)\nu(n)} c - \gamma}{1 + t_c}. \]  \hspace{1cm} (A2)

Second, the derivative of (A1) with respect to \( n \) set equal to zero is

\[ e^{-\rho t} \left( ce^{\beta t} \right)^{1-\gamma} e^{(1-\gamma)\nu(n)} \frac{\nu'(n) - \gamma}{(1-\gamma)} + \lambda (1 - t_n)\omega = 0 \]

or

\[ \lambda = \frac{e^{-\rho t} \left( ce^{\beta t} \right)^{1-\gamma} e^{(1-\gamma)\nu(n)} \nu'(n) - \gamma}{(1-t_n)\omega}. \]  \hspace{1cm} (A3)

By setting the lambda equations equal to each other, or (A2) equal to (A3), we have

\[ \frac{e^{-\rho t} \left( ce^{\beta t} \right)^{1-\gamma} e^{(1-\gamma)\nu(n)} c - \gamma}{1 + t_c} = \frac{e^{-\rho t} \left( ce^{\beta t} \right)^{1-\gamma} e^{(1-\gamma)\nu(n)} \nu'(n) - \gamma}{(1-t_n)\omega}, \]  \hspace{1cm} (A4)

or

\[ \nu'(n) = \frac{(1-t_n)\omega}{(1+t_c)c'}, \]  \hspace{1cm} (A5)
which is Equation (10).

The third step is to find the per-effective-worker law of motion for consumption, \( \dot{c}/c \). To find this we need to consider the costate variable, \( \lambda \), and the state variable, \( k \).

The negative derivative of (A1) with respect to \( k \) is equal to \( \dot{\lambda} \) or \( dH/dk \):

\[
\dot{\lambda} = \frac{-dH}{dk}
\]  
(A6)

or

\[
\dot{\lambda} = -\lambda ((1 - t_k)r - g).
\]  
(A7)

In order to set this dot equation equal to another one we will first take the time derivative of (A2) to get

\[
\dot{\lambda} = \left( \frac{-\rho e^{-\rho t}e(1-\gamma)\beta e(1-\gamma)\mu(n)c\gamma+}{(1-\gamma)\beta e(1-\gamma)\mu(n)c\gamma+} \right)
\]

\[
\frac{(1-\gamma)\beta'\mu(n)c\gamma-}{(1+\tau c)} - \frac{\gamma e^{-\rho t}e(1-\gamma)\beta e(1-\gamma)\mu(n)c\gamma-}{(1+\tau c)}.
\]  
(A8)

After substituting lambda from (A2) into (A7) and setting equal to (A8) we have

\[
\frac{-e^{-\rho t}e(1-\gamma)\beta e(1-\gamma)\mu(n)c\gamma}{(1+\tau c)} = \left( \frac{-\rho e^{-\rho t}e(1-\gamma)\beta e(1-\gamma)\mu(n)c\gamma+}{(1-\gamma)\beta e(1-\gamma)\mu(n)c\gamma+} \right)
\]

\[
\frac{(1-\gamma)\beta'\mu(n)c\gamma-}{(1+\tau c)} - \frac{\gamma e^{-\rho t}e(1-\gamma)\beta e(1-\gamma)\mu(n)c\gamma-}{(1+\tau c)}.
\]  
(A9)

Simplifying (A9) gives

\[
\frac{\dot{c}}{c} = \frac{1}{\gamma} [(1 - t_k)r + (1 - \gamma)\beta'\mu(n)\dot{n} - (\rho + g\gamma)],
\]

which is the law of motion for consumption, or Equation (12).
B  Transitional Dynamics Derivations

To derive the transitional time paths for capital and labor, it is necessary to rearrange the “dot” equations in a form that can be easily linearized around the steady state. We already know the law of motion for capital (Equation (25)) as

\[
\dot{c} = \alpha(1 - tk)k^{\alpha - 1}n^{1 - \alpha} - (\rho + g), \tag{B1}
\]

so we therefore move on to the private capital function. We start with the budget constraint from Equation (9):

\[
\dot{k} = (1 - t_n)wn + (1 - t_k)rk + g_T - (1 + t_c)c - gk. \tag{B2}
\]

It is then transformed accordingly:

\[
\dot{k} = (1 - \alpha)y(1 - t_n) + \alpha y(1 - t_k) + R - (1 + t_c)c - gk
\]

\[
= (1 - \alpha)y - t_n(1 - \alpha)y + \alpha y - t_k\alpha y + t_c c + t_n wn + t_k wk - (1 + t_c)c - gk
\]

\[
= y - t_n(1 - \alpha)y - t_k\alpha y + t_nwn + t_kwk - c - t_c c - gk
\]

\[
= y - t_n(1 - \alpha)y - t_k\alpha y + t_nwn + t_kwk - c - gk
\]

\[
= y - c - gk
\]

\[
= k^{\alpha n^{1 - \alpha}} - c - gk.
\]

Then by dividing by \(k\) gives

\[
\frac{\dot{k}}{k} = k^{\alpha - 1}n^{1 - \alpha} - \frac{c}{k} - g. \tag{B3}
\]

Equation (B3) is equivalent to Equation (27) in the Transitional Dynamics section (2.3).

The next derivation is of the law of motion for labor. The steady-state labor condition (Equation (11)) is

\[
\frac{(1-t_n)w}{(1+t_c)c} = \frac{1+\sigma}{\sigma} \xi n^{\frac{1}{\sigma}}. \tag{B4}
\]
The following step involves taking the natural logarithm of both sides:

\[
\ln \left( \frac{(1-t_n)(1-\alpha)k^{\alpha n^{-\alpha}}}{(1+t_c)c} \right) = \ln \left( \frac{1+\sigma}{\sigma} \xi \eta \right),
\]

which, after expansion, equals

\[
\ln (1-t_n) + \ln (1-\alpha) + \alpha \ln k - \alpha \ln n - \ln (1+t_c) - \ln c = \ln (1+\sigma) - \ln \sigma + \ln \xi + \frac{1}{\sigma} \ln n. \tag{B5}
\]

Now we take the derivative of Equation (B5) with respect to time.

\[
\frac{d}{dt} \left[ \ln (1-t_n) + \ln (1-\alpha) + \alpha \ln k - \alpha \ln n - \ln (1+t_c) - \ln c \right]
= \frac{d}{dt} \left[ \ln (1+\sigma) - \ln \sigma + \ln \xi + \frac{1}{\sigma} \ln n \right],
\]

which simplifies to

\[
a \frac{k}{k} - \alpha \frac{n}{n} - \frac{\dot{c}}{c} = \frac{1}{\sigma} \frac{n}{n}
\]

or

\[
\frac{n}{n} = \frac{a \frac{k}{k} - \frac{\dot{c}}{c}}{\alpha + \frac{1}{\sigma}}.
\]

Next we insert Equation (B1) in for \( \frac{\dot{c}}{c} \) and Equation (B3) for \( \frac{k}{k} \) above to get

\[
\frac{n}{n} = \frac{\alpha \left( k^{\alpha n^{-\alpha} - \alpha} - \frac{\dot{c}}{k} - g \right) - \alpha \left( 1-t_k \right) k^{\alpha - 1} n^{1-\alpha} - ( \rho + g )}{\alpha + \frac{1}{\sigma}}.
\]

This equation simplifies to

\[
\frac{n}{n} = \frac{\alpha t_k k^{\alpha - 1} n^{1-\alpha} - \frac{\dot{c}}{k} + \rho + g (1-\alpha)}{\alpha + \frac{1}{\sigma}}. \tag{B6}
\]

Equation (B6) is equal to Equation (26) in the *Transitional Dynamics* section. We therefore have the three equations ((B1), (B3), and (B6)) that model the dynamics of the economy, which are used to derive the time paths.
### C Parameter Values

#### Table 5
Parameter Descriptions and Values

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>U.S.</th>
<th>AR</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>Output Elasticity of Private Capital</td>
<td>1/3</td>
<td>0.25</td>
</tr>
<tr>
<td>$1 - \alpha$</td>
<td>Output Elasticity of Labor</td>
<td>2/3</td>
<td>0.75</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Constant-Consumption Elasticity of Labor Supply</td>
<td>0.5</td>
<td>1.5</td>
</tr>
<tr>
<td>$g$</td>
<td>Growth Rate</td>
<td>0.026</td>
<td>0.027</td>
</tr>
<tr>
<td>$\xi$</td>
<td>Scalar in Labor Supply Function</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Rate of Time Preference</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Elasticity Factor (Isoelastic Curvature for Consumption)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>$t_k$</td>
<td>Private Capital Tax Rate</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>$t_n$</td>
<td>Labor Tax Rate</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>$t_c$</td>
<td>Consumption Tax Rate (Tax-Exclusive Rate)</td>
<td>0.05</td>
<td>0.21</td>
</tr>
<tr>
<td>$t_{c'}$</td>
<td>Consumption Tax Rate (FairTax Model – Tax-Exclusive Rate)</td>
<td>0.277</td>
<td>0.375</td>
</tr>
</tbody>
</table>
3

Tax Regime Optimality with Money in Utility

The goal of this chapter is to 1) build on the dynamic effects of a tax cut introduced in Chapter 2 while considering seigniorage as another channel of revenue, and to 2) examine optimality given tax allocations – for example, capital, labor, consumption, and inflation taxes of 6.4%, 25.0%, 15.0%, and 3.0%, respectively, lead to utility 15.5% higher yet equal tax revenues to a regime with rates of 25.0%, 25.0%, 5.0%, and 3.0%. This chapter augments the model introduced last chapter by including a money-in-utility function and examining the dynamic scoring effects and optimality in both the U.S. and Argentina – the differences in each country primarily being their elasticity of labor supply, consumption tax rate, and inflation.

The results suggest that tax regimes that place a high importance of collecting tax receipts from private capital and seigniorage (or low weight on labor and consumption) generate lower levels of utility. As discussed below, the distortions resulting from taxes on capital are plentiful and taxing consumption generates the largest utility levels. Theoretically there is no upper bound on a consumption tax since households must consume; however, individuals will not work or build capital stock if taxes on labor and capital are 100%. As such, the labor and capital taxes have the standard Laffer curve shape.

3.1 Model

The model assumes an infinitely-lived representative household that chooses
consumption, $C$, hours worked, $N$, and the quantity of real balances held, $M$, to maximize expected utility; profit-maximizing firms; and a government that balances its budget via government transfers, $g_T$. The basic Ramsey growth model is used to derive steady-state levels of endogenous variables, while considering an elastic labor supply and a tax-collection scheme based on private capital, labor, consumption, and seigniorage.

### 3.1.1 Production Function

As in Chapter 2, the production function has constant returns to scale in competitive input and output markets. The production function and its corresponding marginal products are:

$$y = f(k, n) = k^\alpha n^{1-\alpha}, \quad (1)$$

$$r = f_k(k, n) = \alpha k^{\alpha-1} n^{1-\alpha}, \quad (2)$$

$$w = f_n(k, n) = (1 - \alpha) k^\alpha n^{-\alpha}. \quad (3)$$

### 3.1.2 Government

The government collects revenue from private capital, $rk$, wages, $wn$, consumption, $c$, and seigniorage. The government budget constraint is the same as in Chapter 2 but now includes seigniorage:

$$R = g_T = t_k rk + t_n wn + t_c c + \gamma \pi e^{-\beta(i+\pi)} \text{ Seigniorage}, \quad (4)$$

where $t_n$, $t_k$, and $t_c$ are taxes on labor, private capital, and consumption, respectively. The last term in Equation (4) is the Cagan (1956) form of seigniorage. Inflation, $\pi$, acts as a tax rate and is used to determine the amount of tax receipts stemming from seigniorage.
The exponent in the last term also includes the real interest rate, which is denoted as \( i \).

### 3.1.3 Households

The King et al. (1988) utility function with real money balances is as follows:

\[
U = \int_0^\infty e^{-\rho t} \frac{(cm\beta e^{\gamma t})(1-\gamma e^{(1-\gamma)v(n)-1})}{1-\gamma} dt,
\]

where \( \gamma \) is the curvature parameter, \( \rho \) is the discount rate of the consumer’s time preferences, \( g \) is the rate of labor-augmenting technological change, \( \beta \) is the real money balance elasticity of utility, \( v(n) \) is a differentiable function of labor supply, and \( m \) is real money balances.

The supply function, \( v(n) \), is given as:

\[
v(n) = \xi n^{\frac{1+\sigma}{\sigma}},
\]

where \( \xi \) is a constant greater than zero (set equal to one for simplicity) and \( \sigma \) is the constant-consumption elasticity of labor. Households pay for consumption, \( c \), investment, \( i_k \), and accumulation of real balances, \( a_m \), with after-tax wages, after-tax return on private capital, and government transfers, \( g_T \):

\[
(1 + t_c)c + i_k + a_m = (1 - t_n) wn + (1 - t_k) r k + g_T.
\]

Investment in capital, \( i_k \), is given as

\[
i_k = \dot{k} + gk,
\]

and accumulation of real balances, \( a_m \), is given as \( \frac{M}{p} \), plus existing balances adjusted for the growth rate, \( z \):

\[
a_m = \frac{M}{p} + z \frac{M}{p}.
\]

Substituting Equations (8) and (9) into the budget constraint and converting into per unit
gives:

$$(1 + t_c)c + k + gk + \frac{M}{p} + z\frac{M}{p} = (1 - t_n)wn + (1 - t_k)rk + g_T. \quad (10)$$

Since $\frac{d}{dt} \left( \frac{M}{p} \right) = \left( \frac{\dot{M}}{p} \right) = \frac{pM - MP}{p^2} = \frac{M}{p} - \pi \frac{M}{p}$, we have

$$(1 + t_c)c + \dot{k} + gk + \left( \frac{\dot{M}}{p} \right) + \pi \frac{M}{p} + z\frac{M}{p} = (1 - t_n)wn + (1 - t_k)rk + g_T. \quad (11)$$

In per unit terms this simplifies to:

$$(1 + t_c)c + \dot{k} + gk + \dot{m} + \pi m + zm = (1 - t_n)wn + (1 - t_k)rk + g_T. \quad (12)$$

Rearranging terms gives:

$$\dot{k} + \dot{m} = (1 - t_n)wn + (1 - t_k)rk + g_T - (1 + t_c)c - gk - (\pi + z)m. \quad (13)$$

The above law of motion includes two state variables, $k$ and $m$ (added together can be interpreted as per person assets, or wealth).\(^{21}\) The steady-state equations of the endogenous variables are derived using in a Hamiltonian framework.

### 3.1.4 Steady State

The utility preferences described in Equation (5) subject to the budget constraint in Equation (13) can be used to describe the household maximization problem:

$$H = e^{-\rho t} \frac{(cm^\beta e^{\gamma t})^{1-\gamma} e^{(1-\rho)\psi(n)-1}}{1-\gamma}$$

$$+ \lambda [(1 - t_n)wn + (1 - t_k)rk + g_T - (1 + t_c)c - gk - (\pi + z)m]. \quad (14)$$

With respect to $c$, $n$, and $m$, the following first-order conditions are as follows:

$$\frac{(1-t_n)w}{(1+t_c)c} = \frac{1+\sigma}{\sigma} \xi \eta, \quad (15)$$

$$r = \frac{p + \gamma y}{1-t_c}, \quad (16)$$

\(^{21}\) See Appendix D for first-order condition derivations. Also note that $rk + wn = \gamma$.  

50
\[(\pi + z)m = \beta(1 + t_c)c, \quad (17)\]
\[c = y(1 + \pi e^{-\beta i + \pi}) - gk - m(\pi + z). \quad (18)\]

The steady-state values of the endogenous variables \(y, k, n, r, w, m,\) and \(c\) are fully determined by Equations (1), (2), (3), (15), (16), (17), and (18). Consistent with the literature, that the real money balance elasticity of utility, \(\beta,\) enters Equation (17), which contributes to the elasticity of money demand with the other parameters \((\pi, z,\) and \(t_c).\)

The above system of simultaneous equations is solved with the mathematical software program \textit{Maple} to determine the steady state variables in parameter form. The steady-state revenue function is necessary to derive revenue and utility levels given specified inflation, taxes, and other exogenous parameters.

### 3.2 Revenue Effects with Seigniorage

Before examining the optimality of various tax structures, it will be useful to examine how government receipts change after cuts under varying levels of inflationary distortions. Now that the framework incorporates an additional channel of government revenue, namely seigniorage, it is possible to examine the macroeconomic growth effects from tax cuts via dynamic scoring. The feedback effects from a labor and capital tax cut in Argentina under official inflation levels are much lower than when actual inflation is considered. As mentioned in Chapter 2, the government reports an inflation rate of roughly 9\%, while the consultancies argue it is closer to 26\%. Theoretically, the extra source of revenue from an inflation tax should lessen the requirements to collect for the other channels. Increasing inflation in most developed countries increases seigniorage since they are located on the ‘correct’ side of the Laffer curve. As Bali and Thurston...
(2000) show, it is not unheard of for Argentina to be on the downward portion of its seigniorage Laffer curve. As inflation rises, efficiency losses (e.g. reduced consumption and investment in private capital) become more prevalent.

As can be seen below, the top two tables below (in Table 6) are the results of Chapter 2 while the bottom two are the results from this chapter when considering 3% inflation in the U.S. and 9% and 26% inflation in Argentina. After incorporating seigniorage into the model, the macroeconomic growth effects are larger from consumption, labor, and capital tax cuts. In fact, not only does growth increase as the result of tax cuts with inflation, but a capital tax is nearly self-financing (99%) in Argentina when inflation is 26%.

Table 6
U.S. and Argentine Feedback Effects and Implied Growth

<table>
<thead>
<tr>
<th>Feedback Effects</th>
<th>No Seigniorage</th>
<th>Implied Growth Effects</th>
<th>With Seigniorage</th>
<th>Implied Growth Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>tk</td>
<td>0.389 0.180</td>
<td>tk 61.1% 82.0%</td>
<td>tk 0.375 0.213 0.011</td>
<td>tk 62.4% 78.7% 98.9%</td>
</tr>
<tr>
<td>tn</td>
<td>0.803 0.524</td>
<td>tn 19.7% 47.6%</td>
<td>tn 0.808 0.602 0.528</td>
<td>tn 19.2% 39.8% 47.2%</td>
</tr>
<tr>
<td>tc</td>
<td>0.897 0.763</td>
<td>tc 10.3% 23.7%</td>
<td>tc 0.887 0.693 0.675</td>
<td>tc 11.2% 30.7% 32.5%</td>
</tr>
</tbody>
</table>

Using plausible parameter values, the sensitivity to the real money balance elasticity of utility, $\beta$, of each feedback effect is shown in Figure 11 below. The capital tax has the greatest impact (though minimal) when $\beta$ fluctuates.
Figure 11
Sensitivity of U.S. Feedback Effects to Real Money Elasticity of Utility
Using two as a benchmark for $\beta$ (Hoffman et al, 1995), the seigniorage Laffer curve is given in Figure 12 above. The apex is equal to one over $\beta$ (0.5), which assumes all other rates are held constant. While holding other taxes constant is necessary for deriving the Laffer curve above, it is unlikely that one tax rate would be cut (or hiked) drastically without others changing as well. An extension of this analysis could be to examine how the curve changes as the other tax rates vary as well.

### 3.3 Optimal Utility

In this section, household utility levels are calculated using the steady-state variables derived above and plausible parameter values.\(^{22}\) Utility levels are then compared with varying tax collection scenarios holding revenue constant. Instead of setting the marginal cost of each tax equal to each other to ‘minimize distortions’ as in

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\(^{22}\) See Table 7 in Appendix E for parameter values.
many of the articles outlined above, this chapter will examine (and rank) each tax base’s contribution to household utility. For example, plausible current parameter values for capital, labor, consumption tax, and inflation rates of 25.0%, 25.0%, 5.0%, and 3.0%, respectively, lead to corresponding revenue and utility levels. However, respective rates of 6.4%, 25.0%, 15.0%, and 3.0% lead to equal tax receipts, but utility 15.5% higher.

Some believe that if distortionary sources of revenue are the only means to generate tax receipts, then collecting some amount from each source is the best way to minimize the overall efficiency losses. In other words, if a government wishes to generate a certain level of revenues while inducing the minimum amount of deadweight loss from tax distortions, then it should set policy such that the marginal distortionary cost per dollar of receipts is the same for each tax. As such, Phelps (1973) suggests the optimal combination of taxes should incorporate positive seigniorage, and therefore the monetary policy rule that nominal interest rates be zero, proposed by Friedman (1969), is not optimal. Friedman concluded that in a perfect world – without distortions – inflation would be zero, or even negative (deflation). Once efficiency losses are present, however, inflation levels above zero are optimal.

**Optimal Inflation Tax**

In general, the goal of the social planner, or utilitarian, is to choose a tax structure that maximizes the welfare of the representative consumer. Ramsey (1927) first proposed that tax rates should be implemented solely on commodities and based on consumers’ elasticity of demand for each good – commodities that are inelastic are taxed more. If, however, the social planner is unrestricted to choose any tax system, the optimal outcome
is widely understood to be a lump-sum tax. As Mankiw et al (2009) outline, while this type of situation avoids distorting consumer choices, it also places a tax burden equally among the rich and poor – an unpopular situation from a political standpoint.

Another theory is that capital income ought to have a zero tax rate. As Diamond and Mirrlees (1971) explain, since capital equipment is an intermediate good used in the production of future goods, it should not be taxed. According to Atkinson and Stiglitz (1976), capital taxes should be uniform; as a tax on capital is basically a tax on future consumption and not on current consumption, it is not a uniform tax and therefore suboptimal. While there can be benefits to capital taxation, such as preventing over accumulation, higher capital taxes, in general, lead to large intertemporal consumption distortions that discourage saving and create excessive deadweight losses due to the highly elastic nature of the supply of capital.

Governments most likely do not follow a policy that minimizes deadweight loss given revenue obligations. Mankiw (1987) finds a significant positive correlation between higher tax obligations and inflation rates in the U.S. from 1952 to 1985, implying that governments meet their increasing tax revenue requirements by targeting seigniorage. Poterba and Rotemberg (1990) find conflicting results in other countries and argue that inflation and tax policies change over time and purport that the significant positive correlation Mankiw found is not enough to fully confirm his theory. Mankiw claims himself that his theory only explains one third of the total variation of changes in the nominal interest rate. Additionally, Walsh (2003) outlines the role of nominal interest rate setting by a monetary authority to achieve tax obligations and how it plays a much larger role in non-industrialized economies than in industrialized ones. He also illustrates
that if utility is separable in money balances and consumption that taxing money would be optimal.

Compared to emerging countries with higher inflations such as various Latin American economies, seigniorage’s role as a major revenue contributor in the U.S. is somewhat small. Calvo and Leiderman (1992) therefore examine countries where the inflation tax has played a larger role and exhibit wider variations in government budget deficits, money creation, and inflation. While their results seem to indicate (from a statistically significant standpoint) that the Argentine, Brazilian, and Israeli governments maximize the welfare of the representative individual by equating the marginal social costs of raising revenue through direct taxation and seigniorage, some outlier data points exhibited inflation rates too high to satisfy optimality.

_Taxing the Informal Sector_

Another reason for high inflation in emerging countries might be explained by a typically large informal sector. That is to say, governments are motivated by tax-evading informal economies to promote inflation. Many developing countries have proportionally large informal sectors that remained untaxed from the formal standpoint and an inflation tax is an indirect way of taxing the underground economy via a uniform ‘consumption tax.’ After setting up a model and taking the appropriate first order conditions, Koreshkova (2006) estimates the underground economy using the returns to scale in the informal sector, the ratio of productivity levels in the formal and informal economy, and income tax imposed to the formal sector. She finds that when a subset of goods (within an underground economy) evades taxes, it is optimal for a government to target a positive inflation rate, which is contrary to the Friedman rule of zero inflation being optimal. In
particular, she finds that 4% is the optimal inflation rate for the benchmark economy (the U.S.), which would lead to seigniorage accounting for 2% of total tax receipts. Economies with large informal sectors, 70% for example, should have high inflation (up to 80%) with seigniorage accounting for over half of the receipts.

Koreshkova argues that by setting inflation high in economies with large informal sectors, the distortion from individuals evading labor taxes in the formal sector is reduced. In other words, inflation acts as a uniform tax across both the formal and informal sectors, which increases the tax base and allows a lower tax on formal labor, thereby reducing labor tax distortions. This reduces the incentive for individuals to substitute their human capital into the less efficient informal economy. The optimal inflation rates found by Koreshkova are much higher than those found in Nicolini (1998) and Cavalcanti and Villamil (2003). Nicolini, who, unlike Koreshkova, determines production technologies exogenously, finds that the welfare gain from taxing the informal sector with inflation is insignificant. Furthermore, he estimates that even though Peru’s informal economy represents about 40% of GNP, the optimal nominal interest rate is somewhere between 7 and 19%.

Nicolini breaks up goods into four categories: (1) credit-underground, (2) cash-underground, (3) cash-official, and (4) credit-official goods. Cash-underground and cash-official goods are both subject to an inflation tax, while cash-official and credit-official goods pay both an inflation tax and a consumption tax. Credit-underground goods avoid inflation and consumption taxes altogether. After first order conditions, Nicolini calculates the size for the underground sector, which is relative to official GNP and is based on exogenous values of the capital tax rate, nominal interest rate, government
expenditures, and constants calibrated to estimate the proportional size of all categorized goods. While Nicolini finds the optimal inflation rate for a country like Peru with a large informal sector to be small, he also finds optimal inflation rates for the U.S. ranging from 2.5% to 14%. His results are therefore somewhat ambiguous and contradictory given optimal inflation rates for the U.S. and Peru are not much different.

Not only do Cavalcanti and Villamil report that inflation in economies with informal sectors should be positive, but they provide an analysis of how the structural imperfections affect the welfare cost function. As mentioned above, the Friedman rule of zero nominal interest rates holds without imperfections in input, output, or financial markets; Chari and Kehoe (2002) confirm this with shopping-time, cash-in-advance constraint, and money in the utility function, but when markets are complete. Cavalcanti and Villamil therefore assume markets are exogenously incomplete and examine the results through changing levels of incompleteness.

After first order conditions they calculate a function that relates the informal sector with that of the formal, which can be determined by a parameter that describes the ‘importance of formal and informal labor in production,’ the tax rate on formal labor, and the elasticity of substitution between informal and formal labor. They find that while the optimal inflation rate approaches the Friedman rule for countries like the U.S. with the informal sector accounting for less than 10% of the formal economy, the optimal inflation rate for countries with an informal sector of 55% is 16%. Moreover, in order for emerging countries to justify a lower inflation rate, they will need to improve the structural framework from which to collect tax receipts, so as to avoid distortions from tax evasion.
While the model in this chapter does not include a measure for the informal sector, it incorporates seigniorage into the government revenue function, which allows for examination of how utility levels improve or diminish as inflation changes. In order to examine how utility levels change, while holding revenue constant, the steady-state endogenous variables are used in the following equations:

\[
R^{ss} = t_k r^{ss} k^{ss} + t_n w^{ss} n^{ss} + t_c c^{ss} + y^{ss} \pi e^{\rho (1 - r^{ss} - \pi)},
\]

\[
U^{ss} = e^{-\rho t \left( c^{ss} m^{ss} y e^{\beta_1 (1 - y) (n^{ss}) - 1} \right)}.
\]

As expected, all taxes (including the inflation tax) have a negative correlation with utility; however, tax regimes that place more weight on collecting receipts from consumption generate the most optimal utility levels, especially at high revenue levels. Revenue levels are held constant in Figure 13 below and inflation is kept above zero (or at 1%) for modeling purposes. At benchmark revenue levels (leftmost bar in Figure 13), a consumption tax by itself (with 1% inflation) can produce the same levels yet only taxing labor or capital will not generate sufficient receipts even at peak Laffer rates.
The above figure shows that taxes on consumption derive the most utility, holding revenue constant, especially compared to the base case. In fact, utility is more than 3.5 times greater in this special case. A tax on labor generates the more utility than a tax on inflation and capital, but not consumption. As the proportion of tax receipts collected from sources other than consumption increases, the utility level decreases. Taxing labor is the second-best alternative to taxing consumption. This holds for varying levels of revenue.

These results are consistent with Cooley and Hansen, who find that the distortions from taxes on capital income largely outweigh the distortions from taxes on labor. Using a base case whereby the government only collects revenue from a labor and capital tax, they find that the combined distortions are 13.3% of GNP. If labor tax revenue is replaced by a consumption tax, the distortions are slightly reduced to 12.1% of GNP. If the labor income is replaced by seigniorage revenue, the distortions are reduced to 12.4%.
Additionally, if the capital tax is replaced by a consumption or inflation tax the distortions are largely reduced to 6.6% and 6.7%, respectively. And lastly if government receipts are only collected from a labor tax, the distortions are reduced to 7.8% of GNP. In sum, economies that substitute inflation and capital taxes for taxes on consumption exhibit much lower welfare costs. These results by Colley and Hansen suggest that capital taxes have the largest welfare losses followed by labor and inflation. Taxes from consumption have the least amount of deadweight loss on the economy. This chapter finds that consumption taxes yield the lowest distortions followed by labor, inflation, and capital taxes.

Also, the rightmost bar in Figure 13 doubles the capital tax while leaving the other rates largely unchanged from the fourth bar from the right, but revenue stays the same and utility drops significantly. This can be explained by the very flat capital tax Laffer curve seen below in Figure 14, as compared to the labor tax.

**Figure 14**
Capital and Labor Tax Laffer Curves

![Capital Tax Laffer Curve](image1.png)
![Labor Tax Laffer Curve](image2.png)
On the Argentine side, receipts are 31% higher under an economy with 26% inflation compared to one with 9% inflation. A consumption tax alone generates the most utility as in the U.S. economy, although the welfare gain of moving to a single consumption tax in Argentina is not as large given the already-elevated consumption tax rate of 21%.23

Governments are able to fulfill their budget constraint by issuing currency or imposing taxes on labor, capital, or consumption – each method has its own efficiency loss. High rates of inflation can lead to contracting inefficiencies, while higher taxes can adversely affect saving, investment, and labor supply. The results above indicate some revenue channels distort utility differently. The following text outlines further rational behind each tax’s distortions.

**Labor:**

Households receive income from capital and labor, which can be held in cash or used to consume goods or purchase additional capital. In theory, a higher marginal labor tax rate leads to a decrease in the net return to work, which reduces total hours worked. The deadweight loss that ensues is equal to the value of the lost net output minus the value of extra leisure time to the individual. A higher tax on labor income can also discourage investment in human capital and entrepreneurial behavior. This chapter (as explained in Chapter 2) assumes the elasticity of labor supply is higher in Argentina than the United States – labor taxes in Argentina are more distortionary, and therefore workers are more likely to forego income for leisure when taxes are high.

---

23 The consumption tax rates under a FairTax system in this chapter differ slightly from those found in Chapter 2 given the addition of seigniorage in this chapter. Gamma is also changed to 0.5 for modeling purposes.
Feldstein (2006) argues that the average elasticity of hours worked with respect to after-tax wages (of around one) is widely underestimated because it does not consider the amount of human capital per worker. The level of education, training, experience, effort, and occupation are all factors that make up labor supply – not solely hours worked. As such, when labor taxes increase, the net loss in output is higher than only considering hours worked. Additionally, Feldstein highlights the deadweight loss resulting from workers’ decision to change their compensation structure after tax hikes. In addition to cash, workers receive fringe benefits such as health insurance, ‘comped’ meals, gym memberships, etc. Theoretically, workers increase their consumption of fringe benefits until it is worth one minus the tax rate, or equal to what the worker would receive in after-tax cash. The deadweight loss incurred after a tax hike would be the (high) cost of producing the fringe benefit minus the utility derived by the worker.

Besides depressing the labor output and compensating workers with benefits that are worth less than their cost to produce, Feldstein argues higher labor taxes also cause people to purchase larger quantities of deductible goods. Such examples include mortgages, property taxes, and other tax-preferred consumables. Buying an exorbitant amount of deductible assets, as with consuming fringe benefits, produce a deadweight loss proportional to the reduction in taxable labor income.

**Capital:**

Capital or investment income includes corporate earnings, dividends, interest, and individual capital gains. Per Feldstein, there are two focal distortions resulting from capital taxes: (1) a reduction in net returns to saving that causes retirement consumption to drop and (2) structural inefficiencies that adversely affect individual and corporate
decisions. First, future consumption is reduced because of depressed saving today. This can be illustrated by the concept of compound growth. For example, a 5% reduction in savings today would lead to more than a 5% reduction in saving in the future. In other words, a tax on saving today has a compound effect into the future. A reduction in the future value of capital investment is a disincentive for individuals to work more hours, acquire human capital, and generate wealth today.

The second major distortion of capital taxes has to do in large part with how corporations and individuals operate in an economy. For example, whether or not to pay dividends, whether to open a subsidiary domestically or abroad, whether to finance operations with debt or equity, how to amortize assets, or whether to realize capital gains, to name a few, all must be considered by profit-maximizing investors. One of the most widely accepted distortions arising from capital taxes is the so-called double taxation on dividends. Not only do corporations have to pay taxes on income that can be paid to shareholders in the form of dividends, but individuals must then pay an additional personal income tax on those realized profits. Instead of paying dividends, businesses might decide perhaps to invest in foreign assets, thereby avoiding high domestic tax rates and reducing domestic revenue.

Companies have two options for financing their operations besides reinvestment of net income: debt or equity. Since interest payments on debt are tax-deductible, corporations can be tempted to favor debt over equity. Some argue that private companies might not be as biased since they are not obligated to please shareholders with improved gross margins. That said, when a firm favors debt over equity, it may choose to invest in less-risky/low return investments and reduce long-run growth so as to meet interest
obligations. Inefficiencies occur in this scenario because companies are more vulnerable in volatile market conditions – interest obligations become more difficult to pay. Individuals and corporations may also choose not to realize a profit and reinvest in more prudent assets. A portfolio becomes highly inefficient if investors choose not to reallocate assets due to high tax rates – the portfolio essentially becomes riskier with the same expected return.

*Consumption:*

Some believe (and this chapter confirms) that a tax on consumption comes the closest to ‘temporal neutrality’ than any other type of tax (excluding a lump-sum tax, of course). Temporal neutrality implies that a tax does not change spending preferences or the allocation of resources – after all, the goods that are being taxed are being consumed, not reallocated. When a tax on consumption increases, there is an initial reduction in consumption but increase in saving. Over time, capital stock builds up and consumption increases.

While the U.S. uses a standard sales tax, many countries implement a value added tax (VAT) in order to avoid the distortions created from a standard sales tax. For example, Argentina has a hefty 21% VAT in addition to labor and capital tax rates similar to the U.S.; they also have very elevated inflation, which raises a growing concern about their ability to pay off debt and maintain acceptable levels of education and infrastructure – an issue not addressed in this chapter, but left for further discussion and investigation. A VAT from the standpoint of a buyer is the same as a conventional sales tax – a tax on the purchase price of a good. From the seller’s perspective, a VAT only applies to the value added of the good or service at any point in the manufacturing process. Since a sales tax
implemented by the seller requires the buyer to confirm being an end-consumer, there are minimal economic incentives for the seller to collect the tax if the buyer is not forthcoming. A VAT eliminates the requirement for a seller to confirm that a buyer is an end-consumer.

The overhead and accounting costs are higher for a VAT and businesses realize higher net income under the less-administrative and costly sales tax. Additionally, under a sales tax scheme, only the end consumer is taxed and collected by the seller, whereas in a VAT system the wholesaler and manufacturers have to collect and administer the VAT. This could create a domino effect of increased prices that each step employs to cover the added overhead costs. In theory, a VAT and sales tax generate the same amount of revenue for a government, which is why this chapter and Chapter 2 compare Argentina and the U.S. even though the latter does not use a VAT.

**Inflation:**

Inflation can be a significant source of revenue for governments particularly in developing countries that are trying to drive growth in capital accumulation. Tanzi (1978) reports that the Argentine inflation tax generates 1.2% of GDP when inflation is 10% (reported) or 3.3% when inflation is 30% (actual, according to consultancies). A discrepancy of 210 basis points is not insignificant and 3.3% of GDP is a substantial portion of government receipts considering total revenue is about 20% of GDP. Most often, governments finance capital development through their central banks via money creation. On a basic level, increased money supply raises price levels and diminishes the real value of a currency, thereby acting as a tax on cash balances. Bailey (1956) argues the ratio of the welfare cost to receipts is unfavorably high even at low levels of inflation.
and that there is a misallocation of resources when uncertainty about future prices is introduced. On the other hand, Aghevli (1971) finds that tax revenue from conventional sources (e.g. capital, labor, and consumption) is limited in developing countries and therefore the role of seigniorage becomes more important.

According to Cooley and Hansen (1992), even though the consumption tax can cause distortions from the labor-leisure choice, an inflation tax will do the same in addition to distorting the ‘cash good-credit good’ decision. Similarly, an inflation tax (most notably in high inflation countries such as Argentina) can be costly from an administrative/logistical standpoint (e.g. shoe leather and menu costs). Tobin (1986) even explains the distortions from an inflation tax as “the diversion of resources or loss of utility associated with the scarcity of money.” Some argue, though, that unanticipated inflation is equal to a lump-sum tax and therefore produces a deadweight loss of zero (Makiw, 1987).

3.4 Conclusion

If the goal of tax policy is to collect a certain level of receipts, then why not do so in a manner that yields the highest utility for households? The results formulated in this chapter suggest that the current tax regime is suboptimal. Utility could be more favorable if the capital, labor, and inflation tax rates were replaced by a consumption tax. The above analysis uses the basic Ramsey growth model as well as simulation techniques in Matlab to examine how utility levels can be improved via reallocations of tax rates. This chapter finds that high capital tax rates, and subsequently large portions of tax receipts stemming from the capital tax base, correlate with lower utility. Furthermore, tax receipts
generated from consumption and labor derive more utility than from inflation and capital. If a government had full flexibility in enforcing a tax code, then financing revenue requirements solely from consumption would be the most optimal followed by labor, inflation, and private capital.
D Steady-State “Dot” Equations

Given the utility function, (5), in Chapter 3, subject to the budget constraint, (13), the Hamiltonian setup is given as

\[ H = e^{-\rho t} (cm^{\beta} e^{gt})^{1-\gamma} e^{(1-\gamma)\nu(n)} \frac{1}{1-\gamma} + \lambda[(1 - t_n)w n + (1 - t_k)r_k + g_T - (1 + t_c) c - g_k - (\pi + z)m]. \]  

(D1)

First, the derivative of (D1) with respect to the control variable, \( c \), set equal to zero is given as

\[ e^{-\rho t} (cm^{\beta} e^{gt})^{1-\gamma} e^{(1-\gamma)\nu(n)} \frac{1}{1-\gamma} - \lambda (1 + t_c) = 0 \]

or

\[ \lambda = e^{-\rho t} (cm^{\beta} e^{gt})^{1-\gamma} e^{(1-\gamma)\nu(n)} \frac{1}{1 + t_c}. \]  

(D2)

Second, the derivative of (D1) with respect to \( n \) set equal to zero is

\[ e^{-\rho t} (cm^{\beta} e^{gt})^{1-\gamma} e^{(1-\gamma)\nu(n)} \frac{1}{1-\gamma} + \lambda (1 - t_n) w = 0 \]

or

\[ \lambda = e^{-\rho t} (cm^{\beta} e^{gt})^{1-\gamma} e^{(1-\gamma)\nu(n)} \frac{1}{1 - t_n w}. \]  

(D3)

By setting the lambda equations equal to each other, or (D2) equal to (D3), we have

\[ \frac{e^{-\rho t} (cm^{\beta} e^{gt})^{1-\gamma} e^{(1-\gamma)\nu(n)} \frac{1}{1 + t_c}}{1 + t_c} = \frac{e^{-\rho t} (cm^{\beta} e^{gt})^{1-\gamma} e^{(1-\gamma)\nu(n)} \frac{1}{1 - t_n w}}{1 - t_n w}, \]  

(D4)

or

\[ \nu'(n) = \frac{(1 - t_n) w}{(1 + t_c) c}. \]  

(D5)

which set equal to the derivative of Equation (6) is Equation (15).

Third, the derivative of (D1) with respect to \( m \) set equal to zero is
By setting the lambda equations equal to each other, or (D2) equal to (D6), we have

\[
e^{-\rho t}(1-\gamma)e^{1-\gamma}e^{(1-\gamma)\nu(n)m\beta(1-\gamma)-1} \frac{(\pi+z)}{(1-\gamma)} = \lambda
\]

or

\[
\lambda = e^{-\rho t}(1-\gamma)e^{1-\gamma}e^{(1-\gamma)\nu(n)m\beta(1-\gamma)-1} \frac{(\pi+z)}{(\pi+z)}.
\]

By setting the lambda equations equal to each other, or (D2) equal to (D6), we have

\[
e^{-\rho t}(m\beta e^t)^{1-\gamma}e^{(1-\gamma)\nu(n)c^{-\gamma}} = e^{-\rho t}(m\beta e^t)^{1-\gamma}e^{(1-\gamma)\nu(n)c^{-\gamma}} \frac{(\pi+z)}{(\pi+z)},
\]

which simplifies to

\[
\frac{e^{-\rho t}(m\beta e^t)^{1-\gamma}e^{(1-\gamma)\nu(n)c^{-\gamma}}}{1+t_c} = \beta m\beta(1-\gamma)-1 \frac{(\pi+z)}{(\pi+z)}.
\]

The above equation further simplifies to Equation (17):

\[
m = \frac{\beta(1+t_c)c}{(\pi+z)}.
\]

The fourth step is to find the per-effective-worker law of motion for consumption, \( \frac{\dot{c}}{c} \). To find this we need to consider the costate variable, \( \lambda \), and the state variable, \( k \).

The negative derivative of (D1) with respect to \( k \) is equal to \( \dot{\lambda} \) or \( \frac{dH}{dk} \):

\[
\dot{\lambda} = \frac{-dH}{dk}.
\]

or

\[
\dot{\lambda} = -\lambda((1-t_k)r - g).
\]

The subsequent dot equation is found by taking the time derivative of (D2):

\[
\dot{\lambda} = \frac{-pe^{-\rho t}(1-\gamma)e^{1-\gamma}e^{(1-\gamma)\nu(n)c^{-\gamma}}m\beta(1-\gamma)+}{(1-\gamma)ge^{-\rho t}(1-\gamma)e^{1-\gamma}e^{(1-\gamma)\nu(n)c^{-\gamma}}m\beta(1-\gamma)+} \frac{(1-\gamma)e^{(1-\gamma)\nu(n)c^{-\gamma}}m\beta(1-\gamma)-1}{(1+t_c)}.
\]

After substituting lambda from (D2) into (D10) and setting equal to (D11) we have

71
\[-e^{-\rho t}(m\theta e^{\theta t})\gamma e^{(1-\gamma)\nu(n)c-\gamma(1-t_k)r-g}) = \frac{-\rho e^{-\rho t}e^{(1-\gamma)\nu(n)c-\gamma(1-\gamma)\beta(1-\gamma)+g(1-\gamma)e^{-\rho t}e^{(1-\gamma)\nu(n)c-\gamma(1-\gamma)\beta(1-\gamma)+}}}{(1+t_c)}\]

or

\[-e^{-\rho t}(m\theta e^{\theta t})\gamma e^{(1-\gamma)\nu(n)c-\gamma(1-t_k)r-g}) = \frac{-\rho e^{-\rho t}e^{(1-\gamma)\nu(n)c-\gamma(1-\gamma)\beta(1-\gamma)+g(1-\gamma)e^{-\rho t}e^{(1-\gamma)\nu(n)c-\gamma(1-\gamma)\beta(1-\gamma)+}}}{(1+t_c)}\]

Simplifying (D12) gives

\[\frac{\dot{c}}{c} = \frac{1}{\gamma} [(1-t_k)r + (1-\gamma)\nu'(n)\dot{n} - (\rho + g\gamma) + \beta(1-\gamma)\frac{\dot{m}}{m}],\]

which is the law of motion for consumption – Equation (16) when the dot variables are set equal to zero (the steady state).
## E Parameter Values

Table 7. Parameter Descriptions and Values

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>U.S.</th>
<th>AR</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\alpha)</td>
<td>Output Elasticity of Private Capital</td>
<td>1/3</td>
<td>0.25</td>
</tr>
<tr>
<td>1 (-\alpha)</td>
<td>Output Elasticity of Labor</td>
<td>2/3</td>
<td>0.75</td>
</tr>
<tr>
<td>(\sigma)</td>
<td>Constant-Consumption Elasticity of Labor Supply</td>
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<td>1.5</td>
</tr>
<tr>
<td>(\beta)</td>
<td>Real Money Elasticity of Utility</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>(g)</td>
<td>Growth Rate</td>
<td>0.026</td>
<td>0.027</td>
</tr>
<tr>
<td>(z)</td>
<td>Growth Rate of Real Balances</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>(i)</td>
<td>Real Interest Rate</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>(\xi)</td>
<td>Scalar in Labor Supply Function</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>(\rho)</td>
<td>Rate of Time Preference</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>(\gamma)</td>
<td>Elasticity Factor (Isoelastic Curvature for Consumption)</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>(t_k)</td>
<td>Private Capital Tax Rate</td>
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<td>0.25</td>
</tr>
<tr>
<td>(t_n)</td>
<td>Labor Tax Rate</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>(t_c)</td>
<td>Consumption Tax Rate (Tax-Exclusive Rate)</td>
<td>0.05</td>
<td>0.21</td>
</tr>
<tr>
<td>(\pi)</td>
<td>Inflation (Official)</td>
<td>3%</td>
<td>9%</td>
</tr>
<tr>
<td>(\pi)</td>
<td>Inflation (Unofficial)</td>
<td>3%</td>
<td>26%</td>
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</table>
Argentine Debt Spreads: An Analysis with Global Risk Aversion and Inflation

External funding has become a major driver of state-led infrastructure investment and capital-intensive projects for developing countries, especially in Latin America. Such countries have therefore relied heavily on seigniorage and external bond financing from investors seeking long-term and fixed-rate investments to drive growth. Sovereign debt spreads have increased dramatically during the current European debt crisis, especially for emerging markets. Countries with unstable banking markets and unsustainable debt outlays have been more susceptible to decreased lending and financial instability. This is of crucial concern, as one of the main drivers of economic growth in emerging countries is external financing and, in particular, investment in sovereign debt. As a result, empirical research, aiming to identify determinants of sovereign debt spreads among emerging economies, has grown substantially over the past decade.

Given the similarities between the emerging economies of Latin America that went through a similar meltdown during the 1980s and the turn of the century, and those of Europe currently, it would be useful to see how debt yields persist before, during, and after fiscal instability periods. Latin American markets, like many Eastern European nations, are also notorious for risk of contagion when one country is experiencing financial difficulties. Once a framework to analyze government debt spreads is created, it will provide a way to interpret and draw lessons for the current European crisis. This chapter will use a Structural Vector Autoregression (SVAR) framework and will consider
impulse response functions to show how shocks to fundamental and external factors affect Argentine debt fluctuations. More specifically, this chapter will add an inflation variable (both official and proprietary) to the framework introduced by Garcia and Ortiz (2006).

4.1 Review of the Literature

Identifying determinants of sovereign bond spreads has become an especially salient issue given the current financial instability worldwide. Sovereign debt is government securities that are issued in foreign countries (and usually denominated in foreign currencies). These products trade on the over the counter (OTC) markets, which means the transactions do not pass through a clearinghouse. Debt spreads are defined as the difference between the interest (or coupon) rate of a foreign bond and the interest rate on the “risk-free” U.S. Treasury bond (e.g., 10-year). This spread is the premium investors receive from the added risk of a country's default. In fact, there are two sources of risk on foreign bonds. The first type is the country risk, which is the probability that the country will not be able or willing (e.g., Argentina) to pay back lenders/investors. The second type is exchange rate risk, which is the risk associated with the probability that the foreign currency will depreciate and pay a lower coupon than the investor expects. Both risks, play an important role in the pricing, return, and credit rating of sovereign debt products (Erb, Harvey and Viskanta, 2000; Kamin and Kleist, 1997; Eichengreen and Mody, 1998).

Some argue that internal (or domestic) factors such as the fiscal deficit, government debt, inflation, changes in industrial production or other country
fundamentals are to blame for volatile debt spreads. Others argue that external (or global) factors like corporate bond spreads, global risk aversion, and risk-free interest rates determine debt spreads. Several studies show that internal variables such as fiscal deficits and public debt increase sovereign debt yields (Baldacci et al, 2010, Calvo et al, 1993). The strand of literature emphasizing external factors showed that factors such as risk appetite (proxied by high-yield corporate spreads), global liquidity proxied by U.S. Treasury bonds or the LIBOR (Gonzalez et al, 2008), and capital inflows (Ghosh et al, 1992) are important factors in determining debt spreads.

If the spread on a bond increases, investors might interpret this as an indication that there is now a higher probability of default, which could lead to a country not receiving much-needed funds. But in reality, perhaps the spike in interest rate is in response to central bank policy. Therefore, given the importance of external financing and the volatility of Latin American spreads, it is essential these local government and economic authorities understand the main drivers of bond spreads. A reasonable assumption is that both domestic and global factors play a role in determining spreads. While previous research incorporates both internal and external factors in their analyses, they usually neglect one in order to make and argument for the other.

Min et al (2003) use panel data for fixed-income securities of eleven countries in Latin America and Asia to quantify the effect liquidity, solvency, and macroeconomic fundamental variables have on debt spreads. Unlike most of the previous studies, Min et al use an extensive list of determinants as explanatory variables. They find that the liquidity-related variables have very significant explanatory power, while external shocks such as oil prices do not. Moreover, Latin American countries tend to exhibit an inverted
yield curve. They further confirm that country fundamentals such as those listed above influence sovereign spreads.

Edwards (1985) uses variables, such as industrial production, inflation, and exchange rate, to characterize a country's fundamentals within a logistic framework to calculate the probability of default. The coefficients on the fundamental variables can be estimated using conventional methods (i.e., OLS). More generally, Edwards examines the pricing of international bonds and bank loans, the relationship of default risk premiums with debt and investment levels, and the foreshadowing effects that markets have with regard to debt crises. He finds that within both the international bond and bank loan markets, risk premiums are positively correlated with the debt-output ratio, while negatively correlated with the investment-GNP ratio. Additionally, with respect to the 1980s Brazilian and Mexican debt crises, international markets only weakly anticipate crises a few weeks in advance.

Garcia and Ortiz (2006), construct an SVAR model to examine debt spreads. They find that both external and internal factors have a statistically significant affect on debt spreads in eight countries within South America. They also attribute low risk aversion with low sovereign spreads. Their model is extended in this chapter below to incorporate inflation. Calvo et al (1993) find evidence that increases in U.S. short-term interest rates reduced capital inflows to their sample of ten Latin American countries. Accordingly, falling interest rates and a continuing recession encouraged investors to take advantage of renewed investment opportunities abroad. Ghosh et al (1992) show that externalities such as contagion affect capital inflows – reforms in some countries give
rise to expectations of future outcomes. They also find that a weakening economy can affect a neighboring country.

While most of the literature seeks to identify determinants of sovereign spread fluctuation after bond issuance (or in the secondary markets), some argue that under this scenario the price decision of creditors are weighed more heavily in the pricing of bonds than the decisions of debtors, thus leading to selection bias. Eichengreen et al (1998) therefore consider determinants of spreads at issuance (or in the primary market) such as market sentiment, a dummy variable for whether a country restructured debt with private or official creditors during the previous year, and economic fundamentals. By examining ‘launch’ or initial offer spreads, the problem of selection bias is alleviated because the decisions of both creditors and debtors are considered; new bonds are issued by emerging market borrowers and underwritten by a syndicate of investment banks that need to pitch them to investors. A price (or, inversely, a yield) needs to be appropriate for both the investor and borrower to ensure a successful offering.

Using OLS and probit techniques for data on roughly one thousand developing country bonds issued from 1991 to 1996, Eichengreen et al find that bond issuance for a country is more likely when U.S. interest rates are low, when a country has better credit quality, and when foreign reserves are diminished. Better credit quality is measured by lower debt and budget deficits, while low foreign reserves are assumed to entice country governments to attract foreign funds via bond issuance. Additionally, market sentiment (or the way markets view a country’s ability to repay debt with given characteristics) contributes more heavily to launch spread fluctuation over several months than economic fundamentals even though the latter plays an important role over short periods.
Eichengreen et al therefore argue that while country fundamentals such as Debt/GNP, Debt service/exports, Reserves/GNP and credit ratings have period-to-period tractability to spreads, diversifying foreign funding via foreign direct investment, equity investment, and syndicated bank loans would prove beneficial given the erratic nature of market sentiment and bond financing.

Though Eichengreen et al offer insightful evidence for spread fluctuation, they do not include a measure for global risk aversion or contagion effects, and they do not consider the breakdown of fundamental variables into transitory and permanent components as in Grandes (2007). Grandes finds that changes in the permanent components describe the greatest variation in bond spreads when considering Argentina, Brazil, and Mexico. Furthermore, González-Rozada and Yeyati (2008) find that spread fluctuations are mostly determined by exogenous global factors such as international interest rates and corporate bond spreads. That is not to say that González-Rozada et al do not consider fundamentals. Instead, they conclude that after including differential effects that global characteristics have on specific countries in a panel error correction model for data on thirty-one developing countries ranging from 1993 to 2001, the explanatory power of international interest rates and corporate bond spreads is almost 80% as compared to 10% for fundamental dummies. In other words, the exogenous factors explain close to eighty percent of the long-run spread fluctuation when allowing global elasticities to vary between countries.

Arora and Cerisola (2001) also question Eichengreen’s proxy for global liquidity conditions – 10-year U.S. treasury bonds – since U.S. Treasuries are used in the calculation of sovereign debt spreads and as such cause further concern for endogeneity.
issues. They therefore use the target Federal Funds rate to control for liquidity conditions and the ARCH volatility of three-month treasury bonds differenced with the Federal Funds target rate to control for financial fluctuations. Building from this literature, Alper (2006) uses the Federal Funds future rate as a proxy for global liquidity conditions. He then decomposes U.S. monetary policy into anticipated and unanticipated components so as to estimate their relationship with global liquidity. Using unbalanced panel feasible GLS techniques (Kuttner, 2001), he finds that, unlike the anticipated component, the unanticipated component of monetary policy significantly explains spread movements.

Not surprisingly, higher bond ratings are consistent with favorable country fundamentals such as low inflation, high growth and a history that lacks defaults (Cantor and Packer, 1996; Juttner and McCarthy, 1998). As might be expected, higher bond ratings are also correlated to lower debt spreads. However, some argue that market fluctuations dictate ratings and not vice versa. González-Rozada et al look into how bond ratings affect spreads and find that they merely adapt to spread fluctuations (with a lag) and appear to be endogenous. Furthermore, Ferri et al (1999) argue that a lagged downgrade can exacerbate a country’s probability of default, while Mora (2004) asserts that ratings changes can actually stabilize a country in a weakening economy.

Using panel data estimation of ratings and spreads of 17 emerging market economies, Sy (2001) finds that ratings do not always adjust to market fluctuations. In fact, ratings and spreads adjust differently based on whether the bond spreads are excessively high or excessively low. They find that when spreads are excessively high – as determined by the 95% confidence interval – markets tighten about a month later rather than rating downgrades. Conversely, periods with excessively low spreads come about
three months before a credit upgrade rather than spread increases. Such insight could yield substantial investment opportunities. For example, fitted spread values might be predicted via similar economic fundamentals used by ratings agencies. Therefore, when these values differ substantially from actual market spreads, a savvy investor would act appropriately.

When comparing the debt spreads of countries with different exchange rate regimes (e.g., hard-peg, floating, etc.), a natural question is whether this affects the monetary autonomy of a country. Many economists are in agreement that domestic interest rates fluctuate differently with global interest rates based on an economy’s exchange rate regime. However some argue that interest rates of economies with a hard-peg respond more significantly to global rates (Borensztein et al, 2001; Obstfeld et al, 2004, 2005; Shambaugh, 2004). The countervailing view by others is that actually the more fixed the interest rate the less response domestic rates have to a fluctuation in global interest rates (Frankel, 1999; Hausmann et al, 1999).

In either case, the control over domestic rates governments have while conducting monetary policy is therefore called into question. According to Calvo and Reinhardt (2002), larger governments have more monetary independence than do smaller economies. Moreover, economies cannot have monetary autonomy, open capital markets, and fixed exchange rates simultaneously; they can, however, follow two of these choices (Mundell, 1963). Duburcq (2010) follows by assessing whether a country’s exchange rate regime affects the predictability of domestic rates via internal and external variables. Using a VECM model of 8 Latin American countries she finds that with the exception of
Brazil, countries with rigidly-fixed exchange rates do not suffer largely from decreased monetary autonomy as compared to countries with floating exchange rate regimes.

While SVAR and VECM methodology can provide useful insight into predictive effects of debt yields and overcomes some endogeneity problems, they only look at countries individually. Panel VAR captures time series dynamics and cross-country effects that lead to contagion, thereby avoiding this type of endogeneity. Further research could analyze the impulse response functions of shocks to the fundamental and financial variables to show the importance of each across several emerging countries to better draw parallels to the current European debt crisis.

4.2 Methodology

This section builds upon the methodology introduced in Garcia and Ortiz (2006) in which five equations comprise the SVAR model attempting to explain sovereign debt spreads. Where A and B are matrices, \( e_t \) is the vector of innovations, and \( u_t \) is a vector of shocks that are orthogonal:

\[
Ae_t = Bu_t.
\]

A is assumed to be diagonal and B is shown in the system of equations below, which is overidentified.
The variables are as follows: \( y \) is the level of real activity, \( i \) is the risk-free interest rate, \( \theta \) is global risk aversion, \( d \) is the default parameter, and \( s \) is the sovereign debt spread. U.S. growth is exogenously determined in the first equation. Garcia et al mention that the results do not change if, instead, the U.S. interest rate, \( i \), is exogenous. The second equation in the SVAR model indicates that U.S. monetary policy is determined by economic growth and the risk-free rate.\(^{24}\) As economic activity increases, the expected interest rate should also increase, leading the coefficient in this equation to be positive.

Global risk aversion, as seen in the third equation, is dependent on U.S. growth and the risk-free rate. As U.S. economic activity and the risk-free rate increase, risk aversion should decrease, making the coefficients in Equation (3) negative. Garcia et al allow the possibility for U.S. economic growth and risk-free rate to affect Argentina’s fundamentals, or the default probability, as outlined in the fourth equation. The same assumption is made in this chapter, as it would seem plausible that Argentina’s economic well-being is not independent of macroeconomic conditions in U.S. For the same rational in Equation (3), the coefficients in Equation (4) should be negative – the probability of default decreases as economic activity in the U.S. and the risk-free rate increase.

\(^{24}\) U.S. inflation is excluded for simplicity.
The final equation incorporates global risk aversion and the default parameter for explaining sovereign spreads. It is expected that as the probability of default and global risk aversion increase, the price of government bonds would decrease, leading to higher spreads. As such, the expected signs on the coefficients in Equation (5) are negative. U.S. activity and the risk-free rate affect Argentine sovereign spreads through their impact on the default variable and also on global risk aversion. Spreads are proxied by the JP Morgan EMBI+ index, which measures the total return performance of Argentina’s government bond market.

This chapter extends the Garcia et al SVAR framework by introducing Argentine inflation. In the benchmark system above, external forces, namely U.S. economic activity and the U.S. risk-free rate, affect the Argentine default parameter. This chapter allows for these external factors to also affect Argentine inflation. This relationship can be seen in the Equation (9) below. Additionally, implicit in the SVAR framework is inflation’s role as a determinant of Argentina’s probability of default, Equation (10), and also the price of owning Argentine debt obligations, Equation (11).

**Bauer Model**

\[ e_t^Y = c_1 u_t^Y \]  
(6)

\[ e_t^i = c_2 e_t^Y + c_3 u_t^i \]  
(7)

\[ e_t^\delta = c_4 e_t^Y + c_5 e_t^i + c_6 u_t^\delta \]  
(8)

\[ e_t^\pi = c_7 e_t^Y + c_8 e_t^i + c_9 u_t^\pi \]  
(9)

\[ e_t^d = c_{10} e_t^Y + c_{11} e_t^i + c_{12} e_t^\pi + c_{13} u_t^d \]  
(10)

\[ e_t^\xi = c_{14} e_t^\delta + c_{15} e_t^\pi + c_{16} e_t^d + c_{17} u_t^\xi \]  
(11)

The variables are the same as those of the Garcia model in addition to Argentine inflation.
π. The system of equations above in matrix form is as follows:

\[
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 \\
-c_2 & 1 & 0 & 0 & 0 \\
-c_4 & -c_5 & 1 & 0 & 0 \\
-c_7 & -c_8 & 0 & 1 & 0 \\
-c_{10} & -c_{11} & 0 & -c_{12} & 1 \\
0 & 0 & -c_{14} & -c_{15} & -c_{16} & 1 \\
\end{bmatrix}
\begin{bmatrix}
 e^y_t \\
e^i_t \\
e^\theta_t \\
e^\pi_t \\
e^d_t \\
e^s_t \\
\end{bmatrix}
= 
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 1 \\
\end{bmatrix}
\begin{bmatrix}
 u^y_t \\
u^i_t \\
u^\theta_t \\
u^\pi_t \\
u^d_t \\
u^s_t \\
\end{bmatrix}
\]

### 4.3 Data

The Table 8 describes the variables and their sources. JP Morgan’s EMBI+ index is used to proxy the Argentine debt spread, s. The index tracks total returns for Argentine government bonds, which is the reason for using this index as opposed to using only one bond (or maturity). Global risk aversion (GRA), \(\theta\), measures the overall risk appetite of investors and is proxied by the Baa corporate bond spread. The Federal Reserve Bank publishes this on a monthly basis, which is the frequency used for each variable. The aggregate level of real activity data, \(y\), are collected from the OECD and are used as a leading indicator for global risk aversion. The risk-free interest rate, \(i\), is the 10-year U.S. treasury rate, which was collected from the Federal Reserve Bank. The default parameter, \(d\), is proxied by Bloomberg’s Argentine credit default swap index. The default parameter (as in Garcia) is assumed to consider country fundamentals.
Table 8
Variables and Data Sources

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$s$</td>
<td>AR Sovereign Debt Spread</td>
<td>JP Morgan EMBI+ Index</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Baa Corporate Bond Spread (GRA)</td>
<td>Federal Reserve Bank</td>
</tr>
<tr>
<td>$y$</td>
<td>Aggregate Level of Real Activity</td>
<td>OECD</td>
</tr>
<tr>
<td>$i$</td>
<td>Risk-Free Interest Rate</td>
<td>Federal Reserve Bank</td>
</tr>
<tr>
<td>$d$</td>
<td>Default Parameter</td>
<td>Bloomberg CDS Index</td>
</tr>
<tr>
<td>$\pi$</td>
<td>Inflation (Official)</td>
<td>INDEC</td>
</tr>
<tr>
<td>$\pi_{un}$</td>
<td>Inflation (Unofficial)</td>
<td>Argentine Consultancy</td>
</tr>
</tbody>
</table>

Official inflation rates (based on month over month growth) are collected from the *Instituto Nacional de Estadística y Censos* (INDEC), and the unofficial inflation data are collected from a macroeconomic consulting firm in Buenos Aires.\(^{25}\) The Consultancy collects prices from the four largest supermarkets’ websites on a weekly basis. As previously mentioned these data are quite different than the official pricing data that the governing authority INDEC posts. The Argentine government has retaliated by levying fines of 500,000 pesos to the major consultancies. As can be seen in the revealing figures below, not only are the official inflation estimates (both month over month and year over year) lower than The Consultancy’s estimates, but they are also considerably less volatile. The unofficial yearly data range from 15% to nearly 40%, while the official data are as low as 5% but peaks at 12.3% during the above figure’s four-year time period.

\(^{25}\) Called “The Consultancy” for confidentiality purposes.
The month over month inflation data can be seen below in Figure 16 as well.

The data run from November 2003 until May 2013, with the exception of the proprietary
inflation data, which span the time period November 2007 through September 2012. The summary statistics can be seen in Table 9 below.

Table 9
Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>ds</td>
<td>114</td>
<td>0.5567</td>
<td>7.1278</td>
<td>-33.3745</td>
<td>16.0452</td>
</tr>
<tr>
<td>dy</td>
<td>114</td>
<td>0.0062</td>
<td>0.2820</td>
<td>-1.0138</td>
<td>0.6410</td>
</tr>
<tr>
<td>di</td>
<td>114</td>
<td>-0.0208</td>
<td>0.2256</td>
<td>-1.1100</td>
<td>0.5300</td>
</tr>
<tr>
<td>dtheta</td>
<td>114</td>
<td>-0.0169</td>
<td>0.2383</td>
<td>-0.7800</td>
<td>1.5700</td>
</tr>
<tr>
<td>dd</td>
<td>103</td>
<td>28.60</td>
<td>393.14</td>
<td>-915.50</td>
<td>2855.00</td>
</tr>
<tr>
<td>pi (m/m)</td>
<td>104</td>
<td>0.0074</td>
<td>0.0026</td>
<td>0.0000</td>
<td>0.0150</td>
</tr>
<tr>
<td>piun (m/m)</td>
<td>59</td>
<td>0.0202</td>
<td>0.0101</td>
<td>0.0000</td>
<td>0.0540</td>
</tr>
<tr>
<td>pi (y/y)</td>
<td>47</td>
<td>0.0894</td>
<td>0.0180</td>
<td>0.0530</td>
<td>0.1120</td>
</tr>
<tr>
<td>piun (y/y)</td>
<td>47</td>
<td>0.2603</td>
<td>0.0630</td>
<td>0.1500</td>
<td>0.3880</td>
</tr>
</tbody>
</table>

The variables $ds$ and $dy$ are changes in respective indeces, and $di$ and inflation variables are changes in rates (in percent). The $dd$ variable gives the change (in basis points) of Argentine credit default swaps. The monthly change in Argentine credit default swaps, on average, is 0.28 percent. Notice the monthly change in default swaps has been as high as 28.55 percent, as seen above, which was unsurprisingly in October 2008.

4.4 Results

All of the variables are $I(1)$ except the inflation data, which are $I(0)$, and the real activity data, which are $I(3)$. Due to the sample size of each variable, several time periods are examined. The default data limit the benchmark (Garcia *et al*) and official regressions to October 2004 – May 2013. The proprietary inflation data (based on month to month
growth in prices) run from November 2007 – September 2012. Due to significant financial shocks resulting from the mortgage crisis in 2008, regressions of the benchmark and newly proposed model are shown for the time period October 2004 – September 2008. The SVAR regression results can be seen below in Table 10.

**Table 10  
Regression Results**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Garcia et al</td>
<td>Bausar (Gov)</td>
<td>Garcia et al</td>
</tr>
<tr>
<td></td>
<td>(1.364)</td>
<td>(1.360)</td>
<td>(1.521)</td>
</tr>
<tr>
<td>c4 (y)</td>
<td>0.358</td>
<td>0.053</td>
<td>4.309***</td>
</tr>
<tr>
<td></td>
<td>(1.190)</td>
<td>(1.218)</td>
<td>(0.747)</td>
</tr>
<tr>
<td>e5 (i)</td>
<td>-0.701***</td>
<td>-0.720***</td>
<td>-0.373***</td>
</tr>
<tr>
<td></td>
<td>(0.091)</td>
<td>(0.092)</td>
<td>(0.068)</td>
</tr>
<tr>
<td>i7 (y)</td>
<td>0.033**</td>
<td>0.014</td>
<td>-0.014</td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.015)</td>
<td>(0.023)</td>
</tr>
<tr>
<td>e8 (i)</td>
<td>0.002</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>d31 (y)</td>
<td>2536.771</td>
<td>2719.843</td>
<td>2011.937***</td>
</tr>
<tr>
<td></td>
<td>(2212.916)</td>
<td>(2245.946)</td>
<td>(322.530)</td>
</tr>
<tr>
<td>c11 (i)</td>
<td>-152.290</td>
<td>-140.553</td>
<td>108.260</td>
</tr>
<tr>
<td></td>
<td>(191.040)</td>
<td>(194.011)</td>
<td>(66.985)</td>
</tr>
<tr>
<td>c12 (n)</td>
<td>-1957.580</td>
<td>-1970.030</td>
<td>9506.539***</td>
</tr>
<tr>
<td></td>
<td>(1710.030)</td>
<td>(1710.030)</td>
<td>(3615.149)</td>
</tr>
<tr>
<td>g21 (θ)</td>
<td>3.652</td>
<td>2.796</td>
<td>8.419**</td>
</tr>
<tr>
<td></td>
<td>(2.454)</td>
<td>(2.400)</td>
<td>(3.957)</td>
</tr>
<tr>
<td>c15 (n)</td>
<td>-588.973**</td>
<td>-249.117</td>
<td>-300.7127</td>
</tr>
<tr>
<td></td>
<td>(229.117)</td>
<td>(229.117)</td>
<td>(289.470)</td>
</tr>
<tr>
<td>c16 (d)</td>
<td>0.010***</td>
<td>0.010***</td>
<td>0.037***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.007)</td>
</tr>
</tbody>
</table>

1 The c10, c11, c14, and c16 coefficients equal c7, c8, c10, and c11 in Garcia et al, respectively.
2 Standard errors in parentheses.
3 Statistical significance indicated at the 10% (*), 5% (**) and 1% (***) levels.

**Risk-Free Rate**

There is little doubt within each regression that increased economic activity leads to a higher risk-free interest rate (as seen in the c2 row of Table 10). In other words, a strong economy will see less monetary stimulus and therefore higher interest rates. The
impulse response function in Figure 17 (upper-right panel) shows this relationship. Similarly, the risk-free rate ($c5$) has a (significant) negative effect on global risk aversion. When interest rates are high, as usually seen during boom periods, investors are less risk averse.

**Figure 17**
**Economic Activity IRF**

Inflation

Argentina has been plagued with, what seems to have become cyclical, inflation over the years. Though hyperinflation, as in the early nineties, has not returned, consistent and debilitating price increases have been damaging to Argentina – a country with an unstable financial services industry and an unpredictable government. Heightened prices have not been caused by one single variable, but instead a multitude of factors. For example, recently, cost-push inflation has ensued from a legislative halt of imported goods to the economy. The initial goal was to promote domestic production of
goods and services. While this goal might have occurred on a small scale, it has been at the cost of higher prices (normally kept down from foreign competition) and scarce resources (such as unique hospital supplies and even college textbooks) not immediately available domestically. Another influence on prices has been built-in inflation, which is not new to Argentina given its history with inflation. Simply put, expectations that prices will rise become a driver itself thereby increasing prices and becoming a self-fulfilling prophecy.

To make matters worse, the official inflation data have become overly optimistic, perhaps as a way to reassure people the economy is not worsening. Unfortunately, the discrepancy between actual inflation levels and supposed levels has become too large to warrant any credibility to the official numbers. As such, normal responses to various dependent variables from inflation shocks are not always the case. This can be seen in the differing c7 coefficients, which shows the effect U.S. activity has on Argentine inflation. An active U.S. economy increases official inflation, but actually stabilizes (or reduces unofficial inflation, see Figure 18 below for the corresponding impulse response functions). It would not be unrealistic to assume the Argentine economy is getting stronger when inflation decreases. Supporting this claim are the (significant) negative c10 and c11 coefficients, which say that as U.S. economic activity and the risk free interest rate rise, the probability of an Argentine default decreases. Moreover, the c12 coefficient indicates that as Argentine inflation increases so does the probability of default. In fact, for every percentage point increase in inflation (m/m), Argentine credit default swap spreads rise 1.71 percent (or 171 basis points). Official data are not significant during this time period – likely due to spreads correctly adjusting to the volatile markets and official
data not. Official data show a lower effect (roughly half) during the pre-crisis period and show a negative coefficient (though insignificant) for the full time period.

Figure 18
Inflation IRF

![Image of Inflation IRF](image-url)

While inflation has significant explanatory power for the default parameter, it does not directly have any significance with respect to sovereign spreads (c15). The government pricing data actually finds that inflation negatively correlates with their bond rates. This would imply that Argentine debt becomes more attractive as inflation increases – a very convenient conclusion given the rampant price instability and lack of demand for government debt. The Consultancy data disprove this theory.

Global Risk Aversion

The general lack of significance of y’s effect on global risk aversion (c4) in Garcia et al is also apparent in the results of this chapter. However, during the pre-crisis
period, increased economic activity tended to increase risk aversion, which is not what would be expected. The upper left panel in Figure 19, in fact, shows the effect is initially negative and then grows positive.

Global risk aversion should also cause investors to seek less risky investments than Argentine bonds and as such bond prices should come down (with spreads shifting upwards). GRA and spreads should therefore be positively correlated, however, during the crisis period it is negative. Perhaps global investors were seeking fixed income products outside the US, which would bring the price of Argentine bonds up (and spreads down). The pre crisis the coefficient (c14) is positive, but is negative for the 2007-2012 time period. Interestingly, the impulse functions indicate that the negative effects become positive after roughly five periods. Therefore before and after the crisis global risk aversion exhibits positive effects on Argentine spreads. Figure 20 shows the response of
Argentine spreads to shocks in the other variables.

**Figure 20**

**Sovereign Debt Spread IRF**

Probability of Default

The default parameter explaining sovereign spreads (coefficient c16) is significantly positive in every regression. As the spread on Argentine credit default spreads rise, so do the interest rates on less attractive government bonds. As mentioned above, higher inflation is associated with higher CDS spreads, which are associated with higher bond spreads. Curiously, during the pre-crisis period, an increase in the risk-free interest rate led to heightened default probability for Argentina (c11 coefficient). However (as in Garcia *et al*), using the 2007-2012 data, the relationship becomes negative. The latter explanation would seem reasonable given that in a strong U.S. economy (with a higher risk-free rate), the probability of default becomes reduced. This effect can be seen in Figure 21 below.
Future research might investigate the explanatory power of global risk aversion on the default probability, as there seems to be a large positive effect in the impulse response function above. Reasonably, as investors become more risk averse, the probability of default increases. Each of the impulse response functions above can be seen below next to its corresponding figure with the official inflation rate during the same time period and before the mortgage crisis.
Figure 22
Economic Activity IRF – Pre and During Crisis

Pre Crisis Period

Crisis Period (Official Inflation)

Crisis Period (Unofficial Inflation)
Figure 23
Default Probability IRF – Pre and During Crisis

Pre Crisis Period

Crisis Period (Official Inflation)

Crisis Period (Unofficial Inflation)
Figure 24
Risk-Free Interest Rate IRF – Pre and During Crisis

Pre Crisis Period

Crisis Period (Official Inflation)

Crisis Period (Unofficial Inflation)
Figure 25
Sovereign Spread IRF – Pre and During Crisis

Pre Crisis Period

Crisis Period (Official Inflation)

Crisis Period (Unofficial Inflation)
Figure 26
Global Risk Aversion IRF – Pre and During Crisis

Pre Crisis Period

Crisis Period (Official Inflation)

Crisis Period (Unofficial Inflation)
Figure 27
Inflation IRF – Pre and During Crisis

Pre Crisis Period

<table>
<thead>
<tr>
<th>Impulse Variable, Response Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y, Official Inflation</td>
</tr>
<tr>
<td>D, Official Inflation</td>
</tr>
<tr>
<td>I, Official Inflation</td>
</tr>
<tr>
<td>S, Official Inflation</td>
</tr>
<tr>
<td>Theta, Official Inflation</td>
</tr>
</tbody>
</table>

Crisis Period (Official Inflation)

<table>
<thead>
<tr>
<th>Impulse Variable, Response Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y, Official Inflation</td>
</tr>
<tr>
<td>D, Official Inflation</td>
</tr>
<tr>
<td>I, Official Inflation</td>
</tr>
<tr>
<td>S, Official Inflation</td>
</tr>
<tr>
<td>Theta, Official Inflation</td>
</tr>
</tbody>
</table>

Crisis Period (Unofficial Inflation)

<table>
<thead>
<tr>
<th>Impulse Variable, Response Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y, Unofficial Inflation</td>
</tr>
<tr>
<td>D, Unofficial Inflation</td>
</tr>
<tr>
<td>I, Unofficial Inflation</td>
</tr>
<tr>
<td>S, Unofficial Inflation</td>
</tr>
<tr>
<td>Theta, Unofficial Inflation</td>
</tr>
<tr>
<td>Unofficial Infl., Unofficial Infl.</td>
</tr>
</tbody>
</table>
The orthogonalized response functions are largely insignificant, and as such the contemporaneous effects outlined in Table 10 are the basis for the results in this chapter. The results do not change when considering the cumulative impulse response functions, with the exception of three cases – all of which have to do with economic activity influencing other variables. The significant cumulative results can be seen below in Figure 28 (considering the unofficial inflation data). When economic activity increases, global risk aversion decreases (people become less risk averse) and the probability of default in Argentina is reduced. There is a positive correlation between economic activity and sovereign spreads, which means as the U.S. economy picks up, Argentine bonds become less attractive.
Figure 28
Cumulative Impulse Response Functions

Impulse Variable, Response Variable

Y, D

Impulse Variable, Response Variable

Y, S

Impulse Variable, Response Variable

Y, Theta
The results only change slightly when considering a Cholesky setup – when global risk aversion is inserted into Equations (9) and (10), and economic activity and the risk free interest rate are inserted into Equation (11). Under this framework, global risk aversion no longer becomes a significant predictor of sovereign spreads, but does significantly correlate with the probability of default and inflation in Argentina. As global investors become more risk averse, Argentine inflation increases, while the probability of default decreases. These results are somewhat inconclusive, as global risk aversion is widely believed to be a significant predictor of sovereign spreads and as such, the non-Cholesky setup introduced in the chapter above yields more realistic results.

4.5 Conclusion

Based on the SVAR results and impulse response functions above, global risk aversion and the probability of default have significant impacts on Argentine debt spreads. The results indicate that as investors become more risk averse, they buy less Argentine bonds. Spreads jump up positively after investors become more risk averse and therefore move out of Argentine bonds and into lower-risk assets. That said, Argentine bonds were more attractive after the U.S. mortgage crisis, which can be seen by the negative GRA coefficient (c14) in explaining spreads. The probability of default as measured by the spread on Argentine credit default swaps has a positive impact on debt spreads. Inflation does not have much direct predictive power in explaining Argentine sovereign spreads (not even the proprietary data), but has a significant indirect effect through the default variable (coefficient c12 in the regression results). Additionally, the risk-free interest rate has a significant negative effect on global risk aversion, Argentine
inflation, and the probability of default. In summary, the proprietary data produce results unique from, and in many cases more economically viable than, the official inflation data, which are widely believed to be unrealistic and overly optimistic.
5

Conclusion

The growth effects from tax cuts in both the United States and Argentina are largest when coming from private capital. Moreover, collecting receipts from consumption, as opposed to labor, capital, or inflation, creates the highest level of utility. Though the marginal increase in utility from reallocating taxes into consumption is lower in Argentina than the U.S., it is still economically significant in both countries and feasible from a FairTax standpoint. Incorporating inflation into a dynamic scoring framework shows that a capital and labor tax cut in Argentina finances more of the static loss in the steady state than in the US. Inflation also has more predictive power with regards to Argentina default spreads when using unofficial pricing data as opposed to official data. As investors become more risk averse, Argentine bond prices decrease and rates rise.
Bibliography


Hoffman, Dennis L., Robert H. Rasche, and Margie A. Tieslau. “The Stability of Long-


