A Framework for Evaluating the Macro-financial Stability and Economic Resilience of Small Open Economies

(Preliminary Not for Quotation)

The paper studies the disequilibrium dynamics of an inter-temporal economy with boundedly rational agents operating in markets with financial frictions, which are exposed to unanticipated exogenous shocks. The model incorporates five stylized agents, namely households, businesses, banks, a government, and a credit rating agency. Agents, including the households, government, and banks, are allowed to default on their financial obligations made in an earlier period. In so doing the paper examines the "feedback" relationships between sovereign debt dynamics, the stability of financial institutions, households, and a government in a small open economy. The framework is calibrated to the case of Jamaica and in a set of counterfactual exercises considers the impact on macro-financial stability, and particularly the sustainability of household indebtedness, arising from a fall-out in employment and heightened debt servicing costs. The model does well in developing a causality-driven approach to understanding the spill-over of risks from one sector of the economy to another when the agents interact over time.

Keywords: Systemic Risk, Economic Resilience, Stress Testing, Macro-financial risk model

Author: Jide Lewis Ph.D., CFA, FRM

1.0 INTRODUCTION AND SUMMARY

1.1 Non-technical Summary

Over the last three decades there has been a large number of systemic banking crises of varying sizes, duration and levels of intensity, as documented by the studies of Lindgren, Garcia, and Saal (1996), Pesola (2001), and Kamil and Rai (2009), among others. The persistence of banking sector problems and the large social and economic costs associated with their occurrence have brought to the fore the need for tools and skill sets which can better help policy makers identify and mitigate such risks. Furthermore, over the same period there have also been many sovereign debt crises arising from economies with high levels of public debt. Increasingly this too has received considerable consideration especially in cases where the domestic financial sector and real economic activities, particularly of households, have been negatively impacted.

Reflecting this growing concern, policy makers have focused their attention on developing frameworks which can assess the vulnerability of both developed and emerging economies to debt default so as to allow policy makers to put in place mitigation strategies which can dampen the deleterious impact this can have on both economic activity and financial stability. These considerations are especially relevant to small open economies which are particularly sensitive to exogenous shocks which are inherent in an increasingly interconnected world. Indeed, the high level of indebtedness of households in small open economies has raised many questions for policymakers and the general public. For example, at what level does household debt become too high to be sustainable? By the same token, what policy actions are needed to ensure that debt servicing costs do not result in the need for large write-offs of non-performing loans which in turn could impair the capital base of financial institutions?

This vulnerability was exposed in the aftermath of the September 2008 financial sector meltdown in the United States, where both the non-bank financial sector and the Jamaican Government faced external funding shortfalls. Specifically, the non-bank financial sector faced liquidity short-falls arising from margin calls which resulted from the sharp rise in yields on GOJ global bonds while the GOJ was unable to access global capital markets to meet its financing needs. In response, the central bank intervened in the foreign exchange market in an attempt to manage the sharp depreciation in the domestic currency and provided liquidity to non-bank entities in order to ensure

that all external obligations would be met.[1] The central bank also intervened in the domestic inter-bank market and acted as counterparty to borrowers and lenders to address the problem of asymmetric information which had caused temporary disruption in inter-bank activity.[2] Finally, the central bank tightened monetary policy by increasing its key policy rate to 21 ½ per cent on 1st December 2008. As the central bank attempted to rein in the rapid depreciation of the currency by tightening monetary policy, addressing the price-stability issue on the one hand, it had the unintended consequence of exacerbating the debt-deficit dynamics of the Central Government, on the other. The precarious position of the GOJ during 2009 manifested itself in both a widening of credit spreads viz-a-viz the EMBI (emerging market bond index) as well as successive downgrades of the debt by rating agencies including S&P and Moody's and Fitch.[3] Specifically, On 02 November 2009, S&P lowered its long-term foreign and domestic sovereign credit rating on Jamaica to 'CCC' from 'CCC+' and maintained a negative outlook. On 18 and 24 November 2009, respectively, ratings Agencies Moody's and Fitch also downgraded Jamaica's local and foreign currency government bond ratings. During this period there was also a non-trivial increase in the non-performing loans of house and facilities which were pass due over 30 – 79 days.

It is against this background, both global and local, that this paper intends to make its contribution to the literature on Early Warning Systems (EWS) and Macro-financial Risk Model (MfR models) in the specific area of twin crises of sovereign debt and banking sector distress. The nature of the phenomena to be studied, falls within the ambit of events which are low frequency but have a high (financial and social) impact.

In sum, this paper proposes and estimates a simple model of the debt dynamics of households which projects, on a scenario basis, the likely evolution of the debt-dynamics over the medium-term as well as the vulnerability of the banking sector to credit default. Specifically, a dynamic simulation model is used to evaluate the impact of large but plausible shifts in macro-economic

[1] Between end-September 2008 and end-January 2009 the Net International Reserves (NIR) declined by US$478.0 million or 21.5 per cent. In the following 12-month period, between end-January 2010 and end-January 2009, the NIR then declined by a further 11.2 per cent to US$1566.01 million.

[2] For example, for the trading week ending 24 November and 12 December 2008, the daily quoted 'high' inter-bank rates were 23.4 per cent and 36.2 per cent, respectively compared to tranquil rates of 8.9 per cent in the month prior to the collapse of Lehman Brothers.

[3] On 02 November 2009, S&P lowered its long-term foreign and domestic sovereign credit rating on Jamaica to 'CCC' from 'CCC+' and maintained a negative outlook. On 18 and 24 November 2009, respectively, ratings Agencies Moody's and Fitch also downgraded Jamaica's local and foreign currency government bond ratings.

factors, including the unemployment rate and interest expense on the solvency of the banking sector through a set of counter-factual exercises as measured by the probability of default.

The remainder of the paper is presented as follows: Section 2 gives a brief overview of the crisis literature. Section 3 discusses the development of the macrofinancial risk framework employed in the paper. Univariate stress tests are performed in section 4, and the results of the stress test are explored in Section 5. The paper concludes in section 6 with a discussion of the major policy implications.

2.0 LITERATURE REVIEW

A plethora of models concerning banking crises, primarily game-theoretic in a nature have been developed over the last two decades. These game-theoretic models of financial instability can be broadly categorized as either illiquidity or insolvency models of financial instability. Theoretical models of financial instability that are driven by illiquidity typically depend on some type of 'Domino effect.' That is, in the framework there is usually demandability on the part of one agent (e.g. depositors) or the 'transferability of claims' among agents (e.g. banks). When these rights are exercised, due to the illiquidity of some assets, then this may lead to failures among banks and losses to depositors. See for example the substantive works of Diamond and Dybvig (1983), Allen and Gale (1998), Freixas et al. (2000) and Dasgupta (2004). The main disadvantage of this genre of the bank crisis literature is that crisis outcomes are binary: (i) either all depositors liquidate their holdings and default becomes inevitable, or (ii) nobody liquidates their position and the bank(s) remain solvent. Thus these frameworks show how a crisis could occur but are unable to assist in a forward looking assessment of future crises since there is no accumulation of risk that precipitates the crisis. The second class of theoretical studies considers crises emanating from a rapid fall in the market value of bank assets due to either marking or credit related risks (see for example, Kiyotaki and Moore (1997), Allen and Gale (2000), Acharya and Yorulmazer (2002), Suarez and Sussman (2007) and Morris and Shin (2000)). Several mechanisms have been suggested by this literature for promulgating asset based liquidity crunches including the dissipation of asset values in secondary markets arising from difficulties in a subset of banks which may lead to contagion and co-ordination failure between banks due to highly correlated portfolio choices ex-ante. A chief drawback of this portion of the literature, from a bank surveillance perspective, would be that

almost all of these models have not been calibrated or tested with real data (Goodhart et. al, 2008). Also these theoretical frameworks of bank crises, have implicitly or explicitly assumed that the government issues risk-free assets, and in so doing have not addressed frontally the exposure of banks to sovereign debt instruments in a context where debt dynamics become increasingly unsustainable.

System dynamics has provided a theoretically grounded analytical synthesis between finance and economics that can address these short-comings in the bank crisis literature. The work of Parayno & Saeed (1993) in modeling the dynamics of indebtedness incorporates the macro-economic model of the economy, market-clearing mechanisms and government decision making behaviour. The time-frame is long spanning several decades and the focus is on developmental issues in a context of highly indebted countries with Indonesia as a case study. Similarly, Yamaguchi (2011) presents a system dynamics model of the macro-economy which synthesizes money creation, the banking system, the government, producers and households. The model is used to evaluate implications of the fractional reserve system on economic growth, unemployment and inflation and highlights the significant challenges that growing debt poses to the attainment of macrofinancial stability. The paper explores how a government can effectively manage its monetary system to ensure stability and sustainable economic growth. The paper describes the key components of a public money system, such as the central bank's role in controlling the money supply, managing inflation, and setting interest rates. It also discusses the implications of a public money system for international trade and exchange rates in open economies. Finally framework of Lewis & Dangerfield (2021) discusses policy responses to banking crises induced by sovereign debt issues. It focuses on analysing how policymakers can effectively address such crises to minimize their economic impact. The paper identifies various policy measures that can be implemented, such as debt restructuring, bank recapitalization, and international financial assistance. It highlights the importance of coordinated and timely policy responses to restore financial stability and prevent broader economic downturns. Lewis and Dangerfield's paper offers insights into the challenges policymakers face in addressing sovereign debt-induced banking crises and provides recommendations for designing effective policy responses to mitigate their negative consequences.

3.0 THE MACROFINANCIAL RISK MODEL

3.1 Overview of Model

The government agent developed in this paper builds upon the work of Parayno et. al (1993) and the household and business sector calibrated in this paper elaborates on the seminal work of Yamaguchi (2011) by making the evolution of default probabilities explicit and endogenous and evaluates the transmission of risk between the banking and the household sector. This model however contributes to the literature by explicitly including the role of credit rating agencies and incorporating the dynamics of the evolution of default probabilities (PD) to impact the debt-deficit dynamics in a multi-period setting. Further, the incorporation of the probability of the default allows for the assessment of the impact of large but plausible changes in the macro-economic (and global) environment to be traced to the evaluation of the stability of the financial system.

The model consists of five actors: households, businesses, government, the banking sector, and a rating agency. Households have income from their supply of labour, remittances (unreciprocated earnings), and interest income from savings (deposits held with banks) and investments in government securities (via placements made with financial institutions) and dividends. A proportion of households between the working age group who are not employed receive transfer welfare payments from the government sector. These flows build up their net assets. Households' decisions around whether they should consume or otherwise save/invest for the future is determined as a function of their marginal propensity to save. If households consume more than they earn, then they can opt to borrow from the banking sector in the form of loans. Borrowing of households is governed by an anchoring adjustment process between desired consumption versus actual consumption and the time taken for household to negotiate the terms of the loan agreements with the banking sector. Net assets of households are therefore built up by all the sources of inflows and reduced by consumption, the cost of borrowing and taxes.

For the business sector, their cashflows are increasing in revenues from offering value added goods and services as captured by GDP as captured by consumption and investment activities. Exports of goods and services to the rest of the world also buoy cash flows. On the other hand, the cashflows are decreased by taxes paid to the government sector from profits, depreciation, and wages to workers (households) as well as dividends with a paid to households which have shares

in those corporations as well as dividends paid to those owners which live abroad. If the cashflow of the business sector becomes negative, then they will seek funding from the banking sector or from capital markets to fund investments and inputs into their production process. Therefore, both the repayment of the interest on borrowing as well as return of principal deplete cashflows over time. In turn capital formation in PPE is built up from investments and deteriorates over time due to depreciation. [GDP and Imports serve to increase inventories while exports, consumption and investments serve to deplete inventories].

Households, the government, and the banking sector are assumed to be boundedly rational and backward looking while the rating agency is assumed to be rational and forward-looking. As a result, while the rating agency has access to perfect information and has perfect foresight, the central government and the domestic banking sectors are backward looking and use heuristics to guide decisions regarding debt financing and portfolio allocation, respectively. In the model both the central government and the banking sector and households can default.

Households default risk is captured by its credit risk exposure which is a function of probability of default on its borrowings from the banking sector, the banking sector's exposure to loans to households $\text{EAD}_h$and the loss given default (LGD).

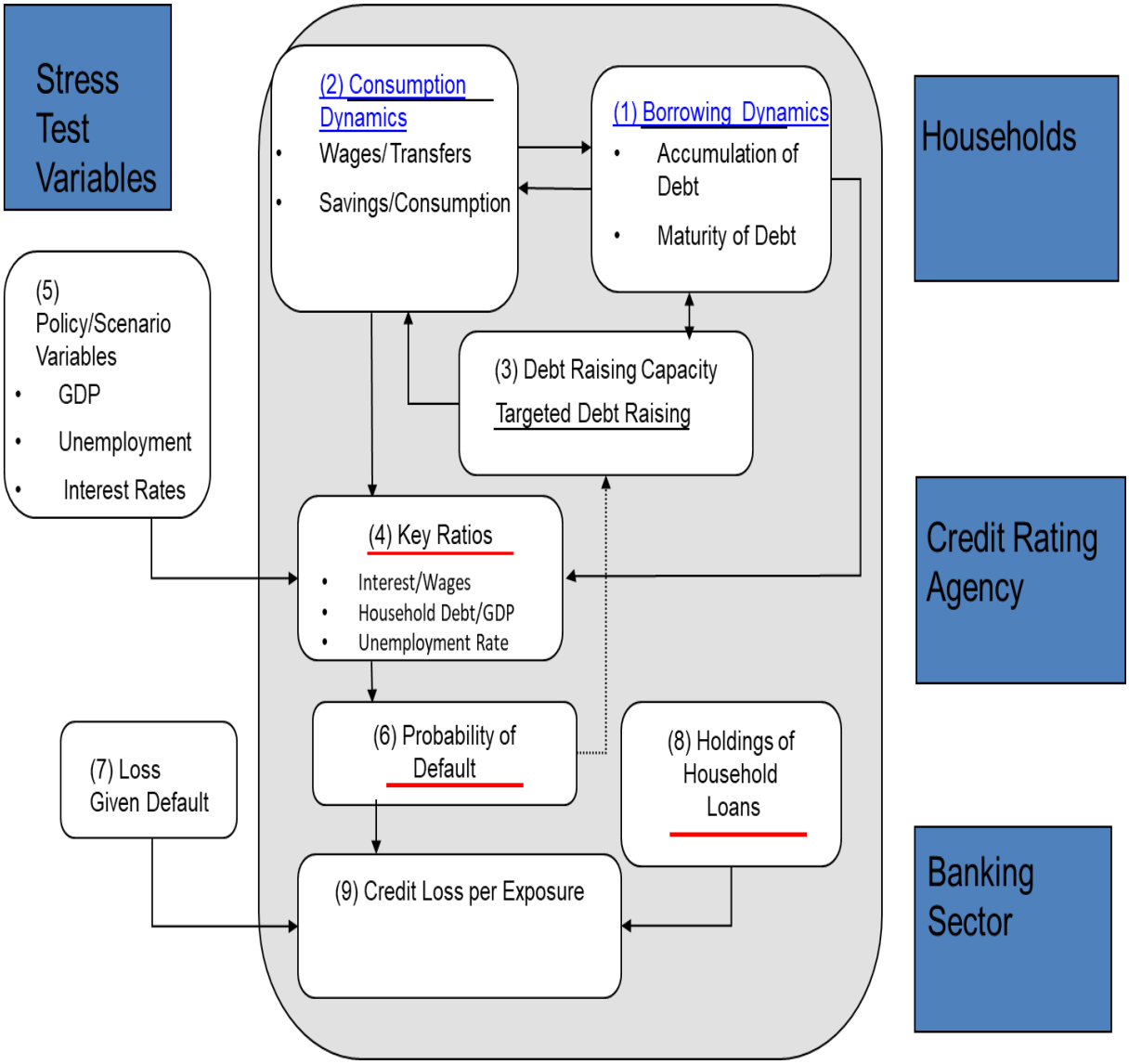
$$CLPE = EAD_h \times LGD \times PD_h \quad (1)$$

The probability of defaults for households will be informed by credit rating agency which assesses the ratio of interest expense to wages, and level of household indebtedness and the level of unemployment, which are all endogenously determined by the model.

$$PD_h = f(\frac{INT_h}{WAGES}, \frac{DEBT}{ASSETS_h}, UNEMP) \quad (2)$$

The banking sector is therefore said to be solvent, if after accounting for the loss in credit arising out of the risk exposure to household loans, the stock of capital of the sector remains non-negative.

Figure 1. Model Overview: Credit Risk from Household Sector



The government will default when the probability of default (PD) issued by the credit rating agency exceeds a critical threshold PD*. The banking sector will default when its credit risk exposure, which is itself contingent on default of the sovereign, exceeds the stock of capital which it holds at any given time. More precisely, a bank will default if, and only if, two conditions hold,

(i) If the sovereign is deemed to have defaulted i.e. PD > PD*

and

(ii) If CLPE > Capital Base (Banking Sector)

where the Credit Loss per Exposure (CLPE) is captured by:

$$CLPE = EAD \times LGD \times PD \quad (1)$$

and the EAD is the exposure to the bank to sovereign debt instruments at the point of default and LGD is the loss given default (the reciprocal of the recovery rate). Care must be taken in the interpretation of the term bank solvency used in this paper. Within this framework, the impact on the solvency of the banking sector is examined by assessing whether or not the sector has a sufficient stock of capital to absorb the credit-loss exposure arising out of an exogenous shock. The banking sector is therefore said to be solvent, if after accounting for the loss in credit arising out of the risk exposure to public debt instruments, the stock of capital of the sector remains non-negative.

Both banks and the government interact via the domestic and international capital markets. The net result is the presence of persistent of debt-deficit cycles on the part of government and local myopia on the part of the banking sector which results in the over-exposure the sector to sovereign credit risk on the ill-conceived assumption that each firm can liquidate their positions in the event of a crisis. This, however, does not hold in the event of a sovereign debt crisis since everyone cannot liquidate their positions simultaneously without having to absorb large haircuts on their positions.

The central government makes decisions about the composition of the debt, the acquisition of financing capital, debt repayments as well as taxation. Modules (1) and (3), Deficit Dynamics and Debt Raising Capacity, both capture the Central Government's financing dynamics, whereas Module (2), Debt Dynamics, captures the debt accumulation process. The Central Government financing module (Module 1) includes variables which capture the rate at which the Government raises taxes and the factors which drive the evolution of recurrent expenditures. These three modules together capture endogenously the evolution of debt and deficits over time (see **Figure 2**).

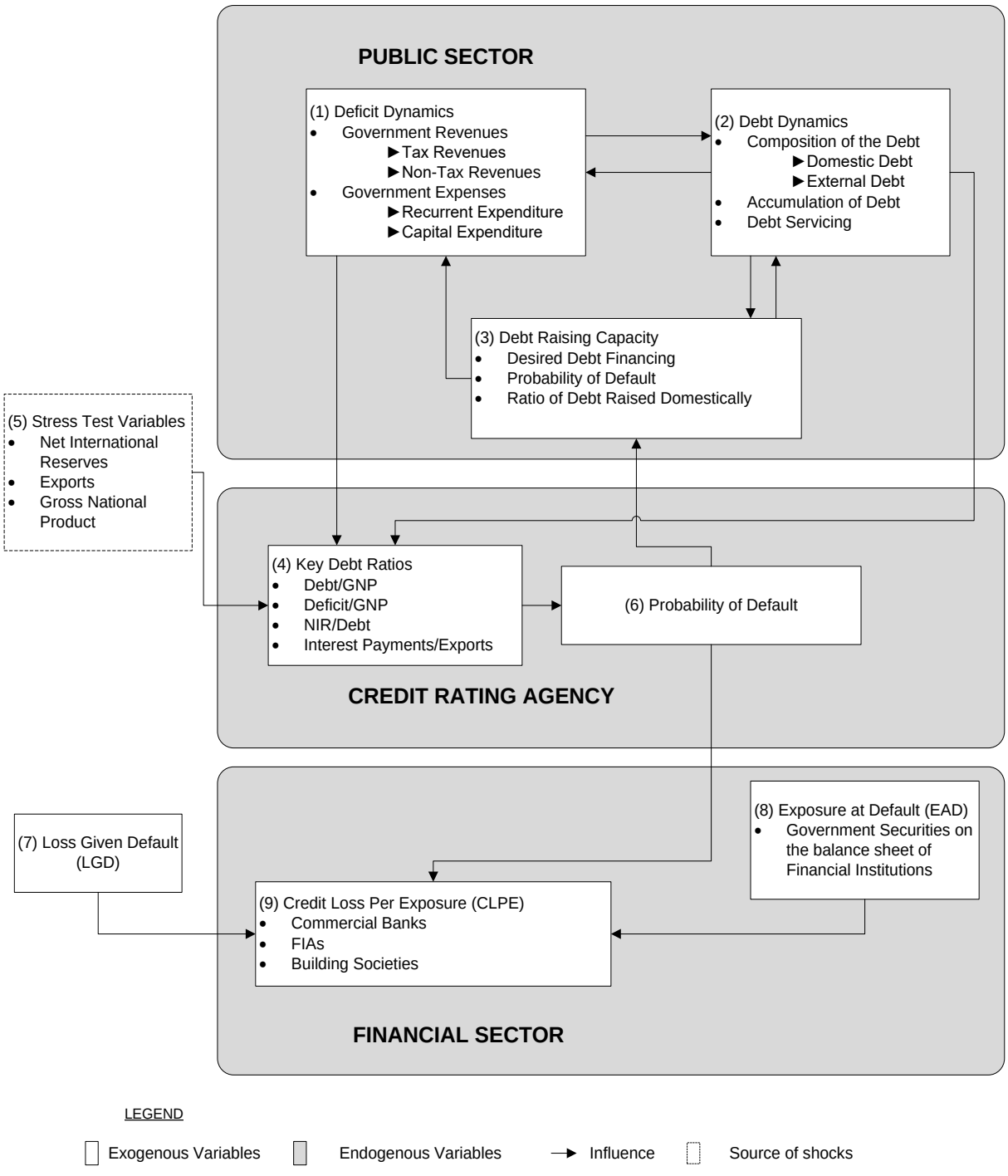
The credit rating agency is assumed to analyze information from the central government performance (modules 1 and 2) along with other macro-economic variables (modules 5 and 6) and make assessments about the credit worthiness of the sovereign (PD). The Probability of Default (PD), module (6), accounts for the credit rating agencies assessment of the likelihood of default on public debt. The rating agency in making its determination evaluates the evolution the sovereign's debt to GNP, deficit to GNP, the stock of NIR to debt stock, and debt service ratio.

The expectations of the agency in relation to these indicators are as follows:-

- Total External debt to GNP ratio (EDTGNP) - An increasing debt stock, compared to resource base (whether GDP, GNP or export earnings), increases the likelihood that the debt is unsustainable and, hence, default is more likely to occur.

- Net government deficit to GNP ratio (DEFGNP). This ratio measures the ability of a government to fund its activities from its own resources. If a government finds its growth in expenses outpacing the growth in the revenues, it is more likely to be hard-pressed to meet its debt-service obligations. Thus, the sovereign is more likely to experience debt repayment difficulties as its ratio of net government deficit to GDP rises.

Figure 2. Model Overview: Credit Risk from Government Sector



- Reserves to debt stock ratio (RESEDT). Foreign reserves serve as a buffer against sudden adverse shocks and indicate the liquidity capacity of a sovereign borrower. A strong international reserve position shows the ability to respond to foreign currency demands in cases of adverse shocks. When reserves are high, it is likely that shocks to the economy can be addressed through a drawdown of reserves. The higher the ratio of foreign reserves to debt, therefore, the lower the probability of rescheduling.

- Interest payments to exports ratio (INTXGS) or the debt-service ratio. The higher the ratio of debt service to exports of goods and services, the greater will be the likelihood that in the event of a severe decline in export earnings the country will no longer be able to meet debt-service obligations.

The rating agencies assessment of the credit worthiness of the sovereign can be summarized in equation 14.

$$PD(t) = f(EDTGNP, DEFGNP, RESEDT, INTXGS) \qquad (2)$$

The agency also considers the reputation of the sovereign in relation to their history of debt servicing in their evaluation of credit worthiness.

The banking sector makes decisions about the evolution of the banking sectors' balance sheet in relation to their holdings of government securities and all other assets. The exposure of the banking sector to sovereign debt default occurs directly through the sector's holding of government securities. For this asset class, the banking sector agents are assumed to use 'pyramiding' rather than portfolio optimization techniques to determine their holdings of government securities. It is assumed that due to the large debt overhang and various regulations the decision by the banking sector to invest in government securities is based primarily on trends based on key performance indicators. The trend function, $g^*(t)$, is based on a behavioral theory of how agents form projections about the future path of key performance indicators. The $g^*(t)$ function involves three

parameters, each the time constant of a first-order exponential smoothing process. The function is given by:

$$g^*(t) = g(TPPC, THRC, TPT) \qquad (3)$$

where g * (t) is expected fractional growth rate of the input variable, TPPC is the time to perceive the present condition, THRC is the time horizon for the reference condition, and TPT is the time to perceive the trend. The evolution of GS and OA on the balance sheets of banks, and consequently banks' exposure to default risk are captured by extrapolating the perceived present condition (PPC) using the expected growth rate, g * (t) , over a one year forecast horizon (FH).

$$GS^*(t) = PPC(t) \times [1 + TPPC \times g^*(t)] \times \exp(FH \times g^*(t)) \qquad (4)$$

and,

$$OA^*(t) = PPC(t) \times [1 + TPPC \times g^*(t)] \times \exp(FH \times g^*(t)) \qquad (5)$$

Finally, the economy is exposed to shocks from varying sources. These shocks include, but are not limited to, contingent liabilities of the government which materialize, sudden declines in gross national product and the country's net international reserves or export activities. Shocks in the framework are assumed to be exogenous and cannot be predicted by any agent. The shocks contemplated in this paper are the net international reserves (NIR), the exchange rate and exports (EXP) and external interest rates.

4.0 BEHAVIOUR REPRODUCTION EVALUATIONS

Figure 3

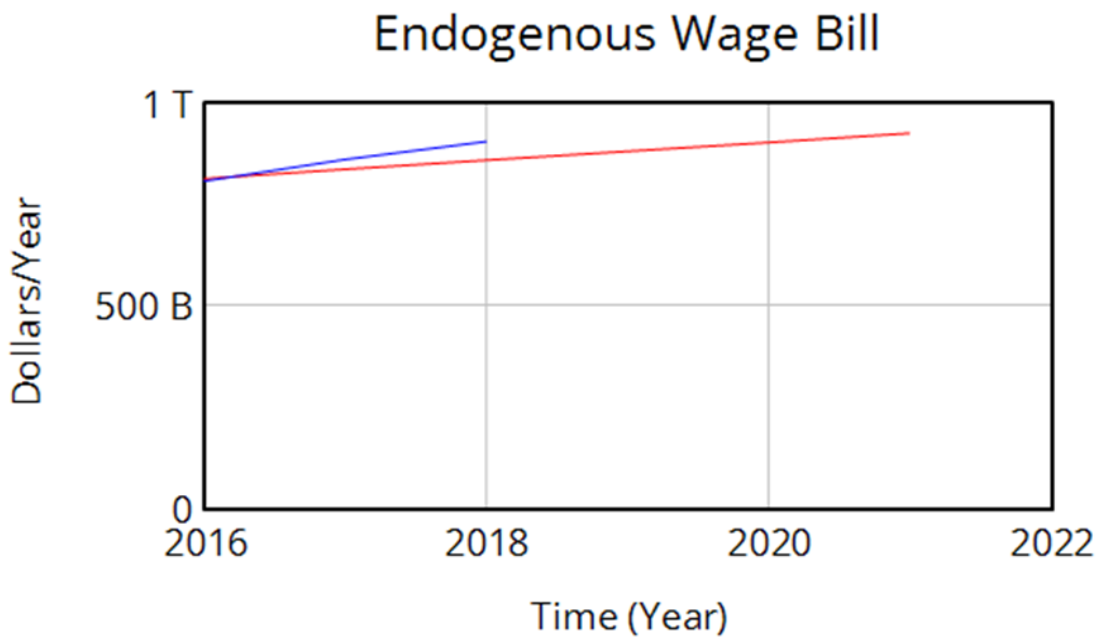


Figure 4

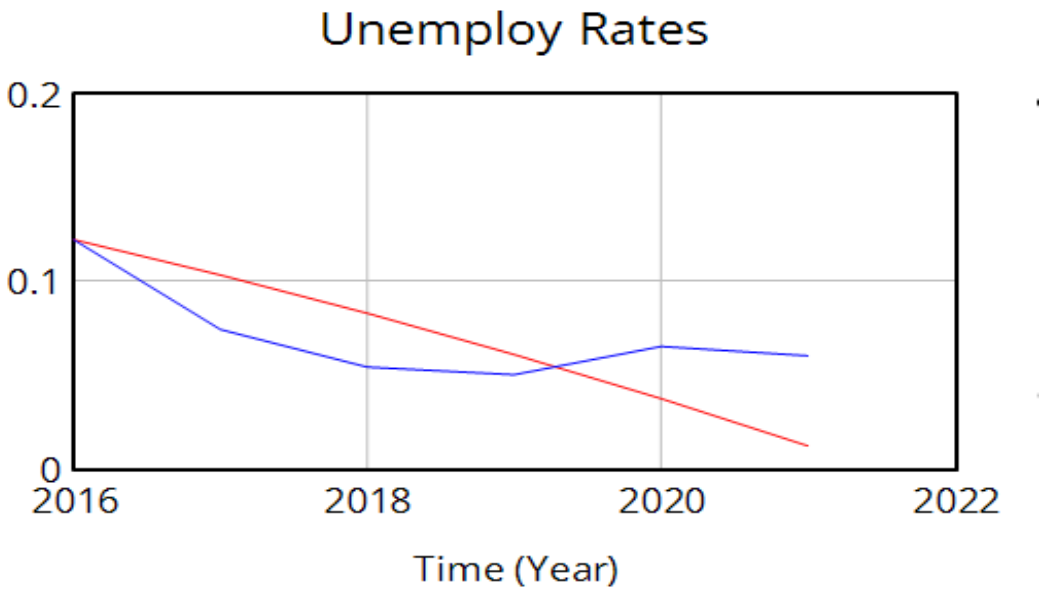
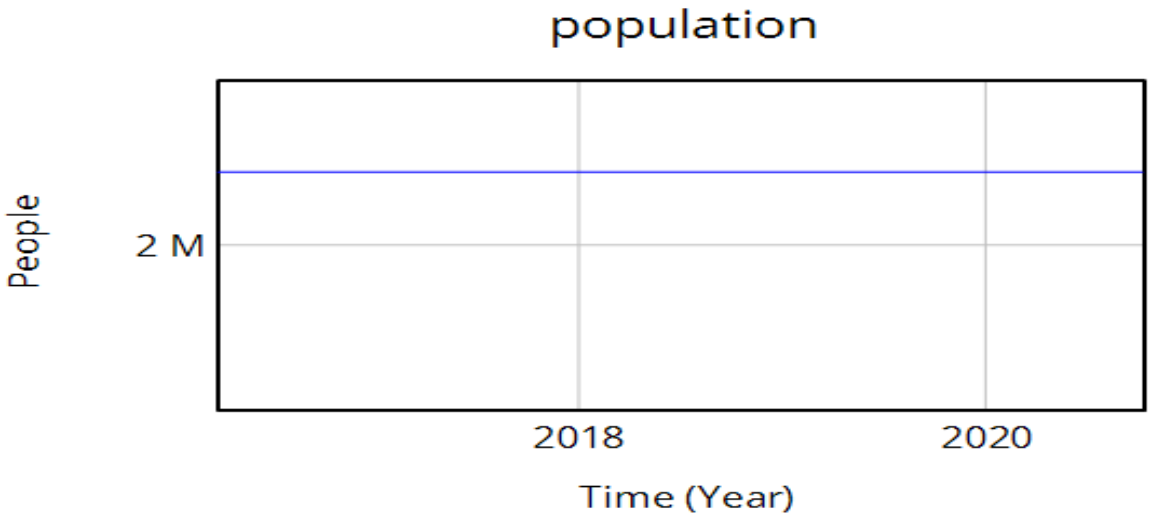
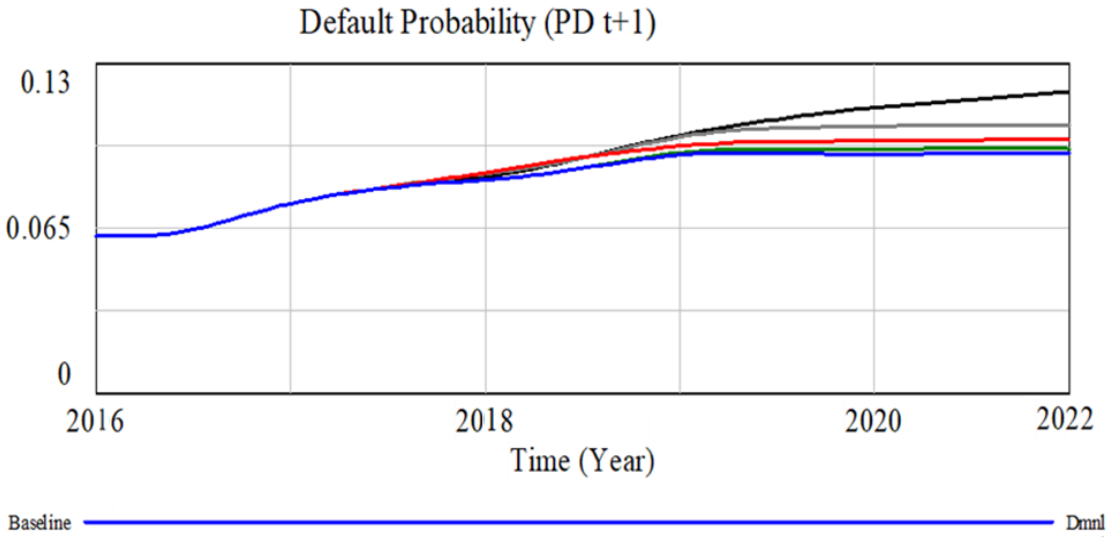


Figure 5



5.0 ASSESSMENT OF UNIVARIATE STRESS TESTS

The impact of the various univariate stress tests on the probability of sovereign default is shown



in Figure 5.5a. The shock to unemployment rates, higher interest costs and well as a one off shock to the level of indebtedness of household as the continue to borrow while unemployed

The mechanism for this deterioration is as follows: - higher debt servicing costs results in the deterioration in the fiscal accounts of the government agent. The deterioration in the fiscal account results in higher levels of debt financing needs of the government agent which serves to

6.0 CONCLUSION

Policymaking is difficult as policy makers typically have imperfect information about which policies produce which outcomes, and they are often left with little choice but to arrive at appropriate policies via a trial-and-error process. The enormity of this challenge increases exponentially when unanticipated shocks and increased uncertainty enters the policy domain.

The literature review section presents a multitude of theoretical models concerning banking crises, categorizing them into illiquidity or insolvency models of financial instability, with references to various scholars such as Diamond and Dybvig (1983), Allen and Gale (1998), Kiyotaki and Moore (1997), and others. These models explore crisis outcomes arising from rapid falls in asset values due to credit risks, and the dissipation of asset values in secondary markets, contributing to liquidity crunches. Moreover, the section discusses system dynamics as a synthesis of finance and economics, referencing the works of Parayno & Saeed (1993) and Yamaguchi (2011) in modelling indebtedness dynamics and macroeconomic variables. This section highlights the limitations of existing theoretical frameworks, emphasizing the need for models that address exposures of banks to sovereign debt in unsustainable debt dynamics contexts.

This paper attempts to model one such policy conundrum, twin household and banking sector stability in the face of unanticipated macro-financial shocks, in a way that is mathematical tractable, rigorous and yet simple enough to be illuminating. However, there are trade-offs in achieving this.

References

Acharya, V., & Yorulmazer, T. (2002). Imperfect competition in the interbank market for liquidity as a rationale for Central Banking. Federal Reserve Bank of New York Economic Policy Review, 8(1), 83-03.

Allen, F., & Gale, D. (1998). Optimal financial crises. Journal of Finance, 53(4), 1245-1284.

Allen, F., & Gale, D. (2000). Financial contagion. Journal of Political Economy, 108(1), 1-33.

Dasgupta, A. (2004). Financial contagion through capital connections: A model of the origin and spread of bank panics. Journal of the European Economic Association, 2(6), 1049-1084.

Diamond, D. W., & Dybvig, P. H. (1983). Bank runs, deposit insurance, and liquidity. Journal of Political Economy, 91(3), 401-419.

Freixas, X., Parigi, B. M., & Rochet, J. C. (2000). Systemic risk, interbank relations, and liquidity provision by the central bank. Journal of Money, Credit, and Banking, 32(3), 611-638.

Kiyotaki, N., & Moore, J. (1997). Credit cycles. Journal of Political Economy, 105(2), 211-248.

Lewis, J, & Dangerfield, B. (2021) Policy Responses to Sovereign Debt Induced Banking Crises: A Model-Based Evaluation of Alternatives, Book Chapter: Feedback Economics, Springer.

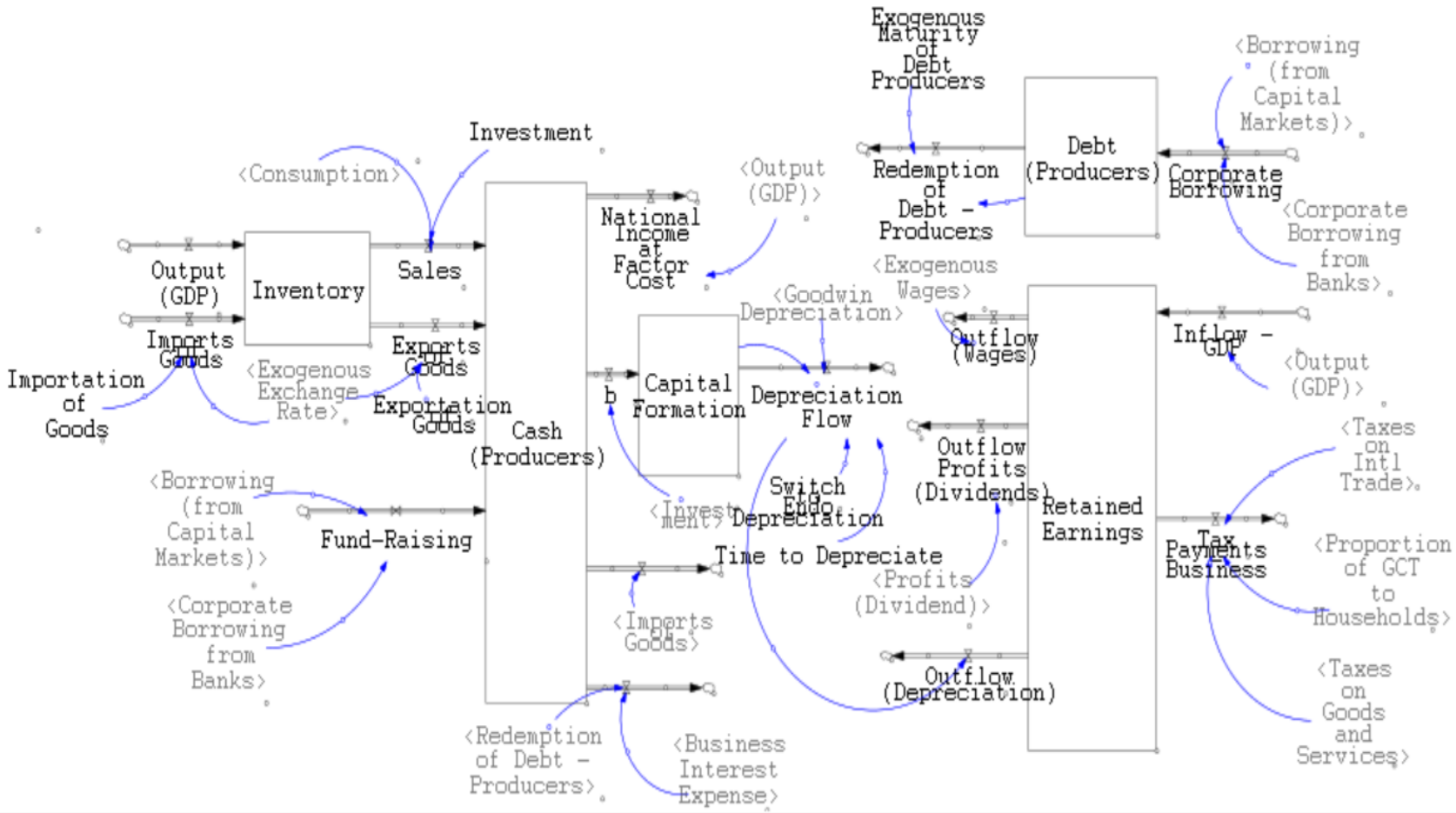
Morris, S., & Shin, H. S. (2006). Catalytic finance: When does it work? Journal of Finance, 61(5), 1703-1745.

Parayno, F., & Saeed, K. (1993). Dynamics of indebtedness in economic development: A system dynamics approach. System Dynamics Review, 9(2), 139-165.
Suarez, J., & Sussman, O. (2007). Endogenous Cycles in a Stiglitz-Weiss Economy with large debt. Journal of Economic Theory, 134(1), 96-118.

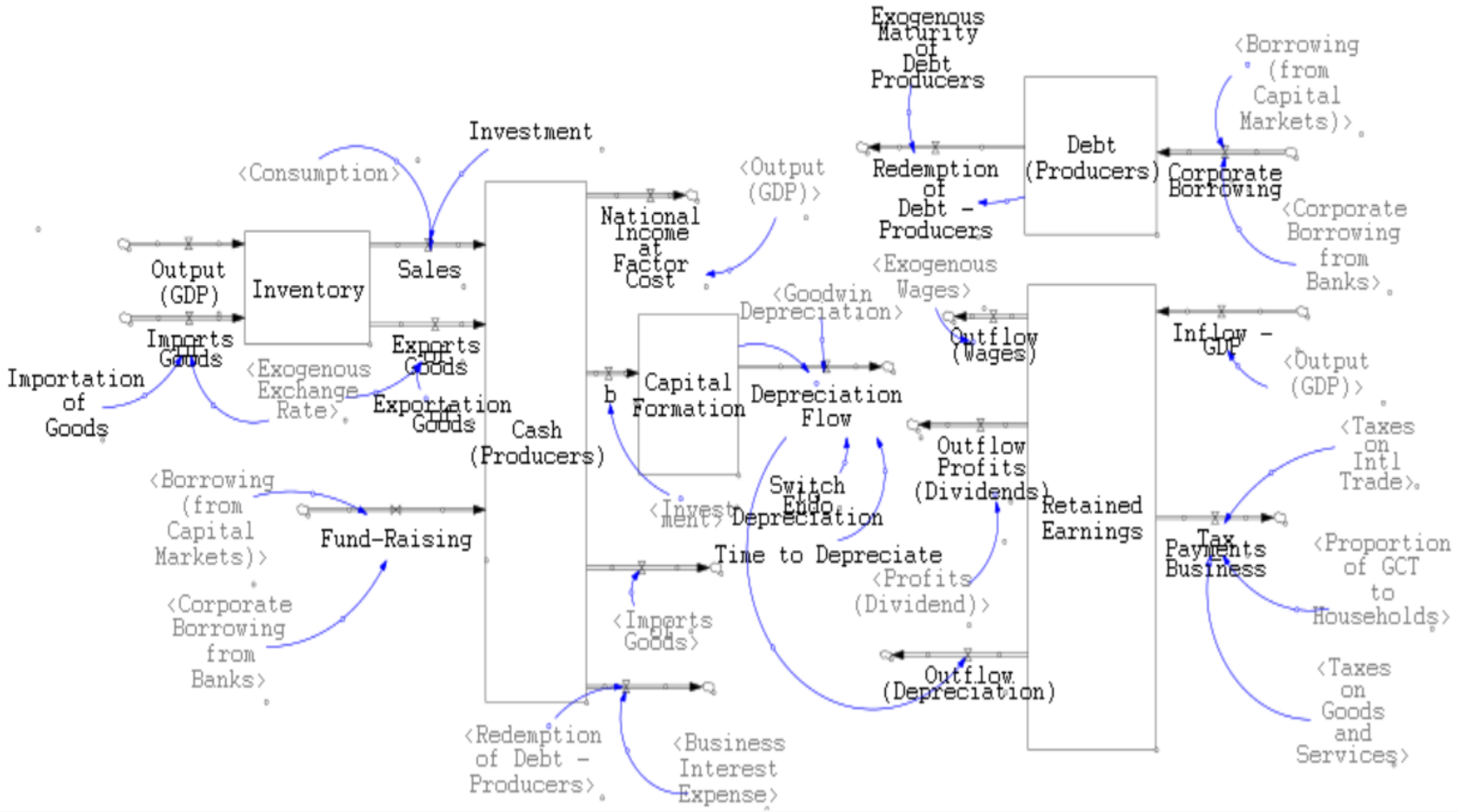
Suarez, J., & Sussman, O. (2007). Endogenous Cycles in a Stiglitz-Weiss Economy with large debt. Journal of Economic Theory, 134(1), 96-118.

Yamaguchi, K (2016). Workings of a Public Money System of Open Macroeconomies, Journal of Economic Issues, 50(4), 1042-1080.

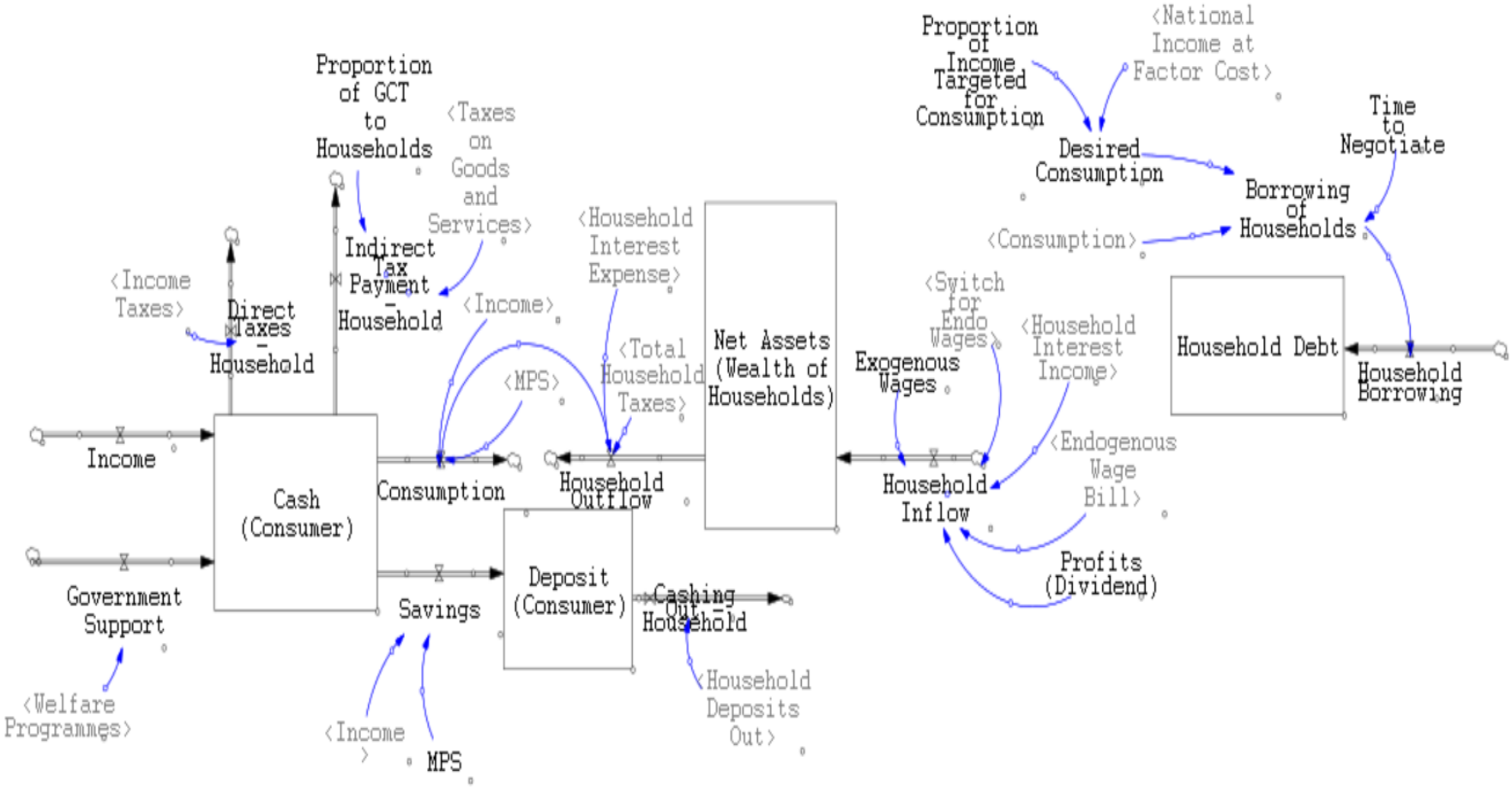
Business Sector



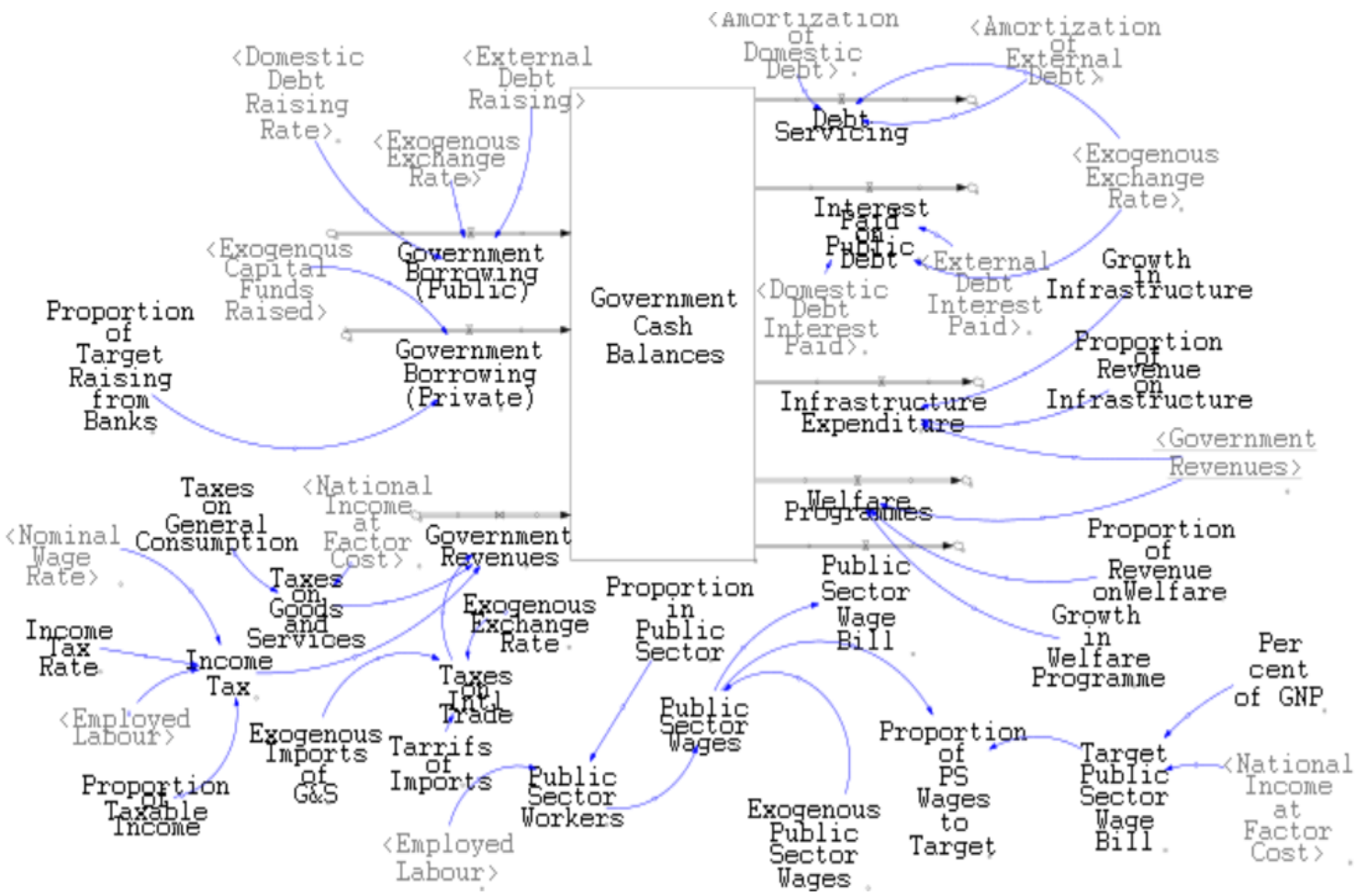
Business Sector



Household Sector



Government Sector



Labour Market