# No More Rocking Horses: Trading Business-Cycle Depth for Duration Using an Economy-Specific Characteristic.

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**Abstract**

Regarding the trade-off between the depth and the duration of recessions, there exists a mounting empirical evidence of the idiosyncratic and non-synchronized behavior of the business cycle over time within and across countries. In this paper, I propose a stochastic dynamic general equilibrium formulation wherein an economy-specific characteristic - labeled as the missing parameter - (e.g., the financial institutional framework and regulations) does control the magnitude, severity and persistence of the business cycle. The results of the simulations show that as much as 0.5 of a percentage point of GDP in depth and a relative difference of 3 years duration can be attributed to this parameter. Overlooked for decades, this missing parameter hypothesizes that Frisch's 'rocking-horse theory' of the business cycle is an inaccurate description of the business-cycle behavior.

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# 1 Introduction

Ever since the seminal paper by Ragnar Frisch (1933), the 'rocking-horse theory' of the business cycle [1] (also referred to as the Cassel paper, after the volume in which it appeared) became the base and the antecedent of most macroeconomists dynamic pursuit to understand and explain business cycles. Build on Wicksell's original [2] idea, Frisch outlined a distinctive separation and a clear dichotomy between the impulse problem and the propagation problem of random shocks that impinge on the economy.

> "There need not be any synchronism between the initiating force or forces and the movement of the swinging system. This fact has frequently been overlooked in economic cycle analysis. If a cyclical variation is analysed from the point of view of a free oscillation, we have to distinguish between two fundamental problems: first, the *propagation* problem; second, the *impulse* problem." Frisch (1933, p. 171)

For the decades that followed, many propagation mechanisms [horses] were proposed to uncover the nature of the business cycle (e.g., see Zarnowitz (1985) for a thorough review). Upheld and implicitly practiced in most macrodynamic research, the framework for analysis centered around the following question. "All business cycle research seeks clarification on a basic, classical question: What are the sources and propagation mechanisms for the boom/bust patterns of economic fluctuations in modern economies?" Quah (1995, p. 1595).

[1] 'If you hit a wooden rocking-horse with a club, the movement of the horse will be very different to that of the club.' Frisch (1933, p. 198). The 'rocking horse model' was received and hailed as a landmark in applied econometrics. Statistical analysis of the business cycle, such as the research by Persons and Mitchell, emphasized the measurement of and attempted to isolate the cycle. For a complete review, refer to Morgan (1995, pp. 92-93).

[2] Frisch reported that the original idea of his model was due to Wicksell. "Knut Wicksell seems to be the first who has been definitely aware of the two types of problems in economic cycle analysis - the propagation problem and the impulse problem - ..." Frisch (1933, p. 138).

Explaining the shape of the business cycle has been (and still is) a concern for researchers.[3] Based on the premise of a 'rigid' impulse problem, - that is once specified at the outset, will not change its characteristics, - and following Frisch dichotomy, most studies argue/propose different propagation mechanisms by which the shock get translated and amplified into a fully developed business cycle. Questions regarding the business cycle are addressed and mostly framed in a 'rocking-horse model', if answered. Racing to the finish line, non-unified strata of models [horses] exist and compete for a universal acceptance.

In this paper, I propose a formulation, wherein the standard benchmark model conforms to Frisch' theory: the impulse is the technology shocks and the propagation is carried through a 'time to build' as outlined by[4] Kydland and Prescott (1982). The suggested formulation allows for an economy-specific parameter that does control the severity [magnitude] and the persistence of the business cycle. By knitting the propagation and the impulse problems into a single parameter, the model proposed here is able to generate different depth-duration trade-offs based solely on the behavior of this economy-specific parameter.

Missing from the bulk of stochastic general equilibrium models, I hypothesize that this parameter is economy specific, in the sense that the shape and format of a country's financial institutions/regulations do contribute to the magnitude and persistence of its business cycles. The parameter serves two functions: it is an integral part of the economy productive capacity [structure], and it controls the degree of persistence of the shock [impulse], therefore this formulation puts into question the merits of the dichotomy, as proposed by Frisch.

[3] Among many, see Harding and Pagan (2002), and Sheffrin (1988).
[4] For the affinities between Frisch's work and Kyland and Prescott (1982), see Hoover (1995).

To re-phrase my proposal in terms of Frisch's physical analogy, I suggest the following example. Not all horses are made with the same materials. Following a shock, wooden rocking horses [dirigiste economy] will rock [swing] more than rocking horses made with soft materials. Soft-material rocking horses [financially integrated and well-developed institutions] will absorb part of the shock, i.e., will swing less. As for the question of persistence, and due to the natural laws of physics, the terminology breaks down, as it is difficult to visualize shock persistence in soft-material made rocking horses.

## 2 Question and Political Economy

Do economic institutions, financial integration and regulations play a role in the shape of the business cycle? If the answer is in the affirmative, then the natural extension to the question is; what kind of role and to what extent do these factors deform the character of the business cycle? In brief, I propose a formulation to answer the following question. What is the influence of an economy-specific parameter on the shape of the business cycle? Here, I focus on the shape of the business cycle as articulated by its depth and its duration. [5]

Identifying the nature and character of the business cycle is of importance to political economists. One constant in globalization research, is that both sides - opponents or proponents of economic reforms - agree that these economic reforms bring economic growth and a deformation of the *character* of the business cycle. [6]

[5] The question posed here is different and broader than the one examined in Mikhail (2003), wherein the business cycle consequences of undertaking an economic-reform agenda (as proposed by the 'Washington Consensus') are addressed.

[6] In this paper, I abstract from the debate regarding the proper or appropriate 'sequencing' of

A direct consequence of the suggested hypothesis in this paper, is that a dirigiste economy might face a higher risk of political instability (Blomberg and Hess (2002) and Farr, Lord, and Wolfenbarger (1998)). To protect its governing economic power, a dirigiste economy that resists economic liberalization might end up with a higher probability of political instability in a self-defeating mode and a self-fulfilling prophecy. Due to the nature, extent and functions of its economic institutions, a dirigiste economy does not absorb much of the shock, and suffers from a higher amplitude [larger business cycle swing] that creates a fertile environment for political instability. [7]

## 3 Review of the Literature

The motivation of the paper builds on a paramount business cycles [empirical] studies that reported evidence of idiosyncratic and non-synchronous behavior regarding the magnitude and the persistence of the cycle. The empirical fact of changes in the severity and persistence of business cycles is well documented and concede at a varying rate to the evidence suggesting that business cycles are no longer similar, nor linked, over time within or across countries. For the U.S., a moderation in output fluctuations is observed. Blanchard and Simon (2001), Kim and Nelson (1999), McConnell and Perez-Quiros (2000), Ramsey and Rothman (1996) and Stock and Watson (2002a) reported evidence of changes in the character of the U.S. business cycle. In international data, output volatility and the non-synchronous behavior

economic reforms measures (See Edwards (2000, 2003) and Stiglitz (2002)). As an interesting agenda for future research, is to investigate how different 'sequencing' leads to different *characters* of the business cycle.

[7] See Blomberg and Hess (2002) wherein they reported strong evidence of dependence between internal conflict, external conflict, and the state of the economy. Their results suggested that recessions can provide the spark for increased probabilities of internal and external conflict.

are documented in Ambler, Cardia and Zimmermann (2004), Artis, Kontelemis, and Osborn (1997), Artis and Zhang (1997, 1999), Carvalho and Harvey (2002), Clark and Shin (2000), Dalsgaard, Elmeskov and Park (2002), Del Negro and Otrok (2003), van Dijk, Osborn, and Sensier (2002), Doyle and Faust (2002a, 2002b), Fritsche and Kouzine (2003), Heathcoate and Perri (2002), Helbling and Bayoumi (2003), Helg et al. (1995), Kose, Prasad, and Terrones (2003), Luginbuhl and Koopman (2003), Mills and Wang (2000), Simon (2001). For a complete summary and a thorough analysis of the empirical facts, see Stock and Watson (2003). Regarding the trade-off between depth and duration, Edwards, Biscarri and de Gracia (2003) concluded that cycles in emerging countries tend to have shorter duration and larger amplitude/volatility than in developing countries. For the period of post financial liberalization, the study reported that Latin-American stock markets behaved similarly to stock markets in developed countries whereas Asian countries have become more dissimilar.

In this paper, I argue that economic institutions that are specific to each economy - e.g., structure of the financial institutions, economic policy and regulations - hold the key to the shape of the business cycle. If two economies, one that is institutionally well-developed and the other is under-developed, face the same negative exogenous shock, then the institutionally developed one will have a cycle that displays: lower amplitude and longer duration. To confirm with the empirical facts presented in the literature, I hypothesize that this missing economy-specific parameter could be similar in value at a group-level of countries.

What makes two similar economies behave differently when faced with the same shock? for example, the Canadian and the U.S. economies exhibit different business cycle characteristics to the extent that few have argued that it must have been different shocks that impinged on

both. With similar technological trends in Canada and the U.S., it is unlikely that technological change can lead to a relatively high and persistent unemployment in Canada when it does not have that effect in the U.S. (Sharpe (1999, p. 31)). I view this argument as inaccurate for the following reason. It is widely accepted that both countries tend to face similar technological trends, the Canadian economy is characterized by relatively different institutional structures and public programs, - e.g., the independence of the Bank of Canada relative to the Federal Reserve System, and the deregulation regarding financial institutions. Also, relative to the U.S. economy, some industries are non-existent in the Canadian economy and others are under-represented. In terms of existence and functioning, these gaps impinge on the speed of recovery during a recession. I argue that, faced with a technology shock similar to that in the U.S., the Canadian economy will experience higher persistence in terms of output and unemployment deviations. This relative higher persistence of the business cycle can be captured by the missing parameter as a function of the financial institutions structure and public programs in Canada.

There are few empirical studies that suggested an institutional root/cause to the changes in business-cycle fluctuations and focused on institutions as the primary source of profound influence on economic development. Acemoglu et al. (2003, pp. 89-90) noted that "Our interpretation of these results is that a fundamental determinant of thirty-year volatility differences is institutional differences across countries, and that institutional differences create economic instability through a variety of microeconomic channels as well as the often-emphasized macroeconomic channels." Artis et al. (2003) acknowledged the role of institutions in dating the business cycle. Djankov et al. (2003) studied the structure of efficient institutions, and

the politics of institutional choice and their influence on economic development.

The missing parameter suggested here is time and country dependent. As countries revise and change the functioning of their institutions over time, the shape of the business cycle changes accordingly. As countries close the functioning gap between their institutions, their business cycles become similar. [8]

My attempt to theoretically capture institutional influence on economic volatility is not without empirical evidence. Across the U.S., Morgan, Rime and Strahan (2003) examined economic volatility and its relation to banking integration. They investigated how the better integration of U.S. banks across states has affected economic volatility within states. Their hypothesis was that bank integration tends to dampen the impact of bank capital shocks on state activity, but it amplifies the impact of firm collateral shocks. Empirically, the net effect has been stabilizing, as year-to-year fluctuations in employment growth within states fall as that state's banks become better integrated (via holding companies) with banks in other states. These magnitudes are large, and the effects are most pronounced in states with relatively undiversified economies.

## 4 The model and Results

The economy is characterized by a large number of identical consumers. The single consumer is assumed to be representative [9] of the society as a whole. Representative agents' preferences

[8] See Helbling and Bayoumi (2003) for the empirical evidence regarding the Euro zone.
[9] For a comprehensive development of the representative agent in macroeconomics modeling, refer to Hartley (1997).

are represented by a utility function which is time separable in consumption and leisure, and it is state independent. The representative household solves the following problem.

$$\max_{(c_t,n_t,k_{t+1})_{t=0}^{\infty}} E_t \left\{ \sum_{t=0}^{\infty} \beta^t (\log c_t - \gamma n_t) \right\} \tag{1}$$

subject to,

$$y_t = \frac{1}{\mu} A_t k_t^{\alpha} n_t^{1-\alpha} \tag{2}$$
$$k_{t+1} = (1-\delta_k) k_t + i_t \tag{3}$$
$$\log A_{t+1} = (1-\psi\mu) \log \overline{A} + \psi\mu \log A_t + \epsilon_{t+1} \tag{4}$$
$$c_t + i_t \leq y_t \tag{5}$$
$$l_t + n_t \leq 1 \tag{6}$$

$c_t$, $n_t$, $l_t$, $k_t$ and $y_t$ refer to consumption, labor, leisure, capital and output, respectively. $E_t$ refers to the expectation operator. $A_t$ denotes the technology shock. The subjective time discount factor $\beta$ is constrained to $0 < \beta < 1$ and is defined as $\beta \equiv 1/(1+\rho)$, where $\rho$ is the rate of time preference. $\alpha$ and $\delta_k$ refers to the capital share in income and the capital depreciation rate, respectively. There is one final good in this economy, and it is produced according to a constant returns to scale neoclassical production function given by Equation (2). Equation (3) is the capital law of motion, i.e., 'time to build' for capital. Equation (4) describes the evolution of the technology shock, and $\epsilon_t$ denotes white noise. Equations (5) and (6) are the resources and time constraints, respectively.

I integrate an exogenous economy-specific parameter into a standard real business cycle model to investigate the merit of the 'trade-off between depth and duration' statement. Of interest to the hypothesis proposed in this paper, the parameter $\mu$ is constrained to the interval $0 < \mu \leq 1$ in equations (2) and (4). $\mu$ refers to the missing parameter that controls

the shape of the business cycle. Think of $\mu$ as an absorption rate parameter. A higher value for this parameter is equivalent to a higher absorption rate of the technological shock. In other words, the higher $\mu$ is, the lower is the amplitude of the business cycle swing and the more persistent is the business cycle. Here, I assume that $\mu$ is exogenous and it could be identified and estimated using both: the economic freedom index and the Solow' residuals, for example. This parameter is endogenous to the institutional and regulatory framework operating in the economy. Further studies can address the endogeneity, identification and estimation of this parameter.

Note that if $\mu = 1$ (no absorption), then the proposed model reduces to a standard real business cycle model, wherein $0 < \psi < 1$ is the sole parameter that control the persistence of the shock.

Subjected to a stochastic technology shock $A_t$, the structure of the economy absorbs part of this shock $(1/\mu)$. Also, the structure of the economy controls how persistent the shock is ($\mu$ in Equation (4)). As for how the economy absorbs and controls the persistence of the shock, I assume that it is due to the nature, extent and functions of its institutions. In this setup, an institutionally well-developed structure (i.e., a higher value for $\mu$) will cushion the depth of recessions.

The model is solved and simulated with sensitivity to the structure following Uhlig (2001, p. 38). The log-linearized system is solved using numerical rational expectations (see the Appendix, Section 7). The calibrated parameters are chosen to ensure that the capital to output steady state value matches the U.S. sample data. The quarterly calibrated parameters used to generate the impulse responses are: $\beta = 0.99$, $\alpha = 0.36$, $\delta_k = 0.025$ and $\psi = 0.95$. $\beta$

is set to imply a steady-state real interest rate of 1 percent per quarter. $\alpha$ is set to match the average fraction of total income going to capital in the U.S. economy. The depreciation rate ($\delta_k$) is set to imply a steady-state ratio of capital to output of approximately 10 and a ratio of investment to output of 0.26. $\psi$ and the standard deviation $\sigma_\epsilon = 0.007$ are set equal to the same value used by Prescott (1986). $\gamma$ is computed from the steady-state and equals 2.5.

There is no single point estimate for the parameter $\mu$, therefore I address this issue by calibrating the model with different set of points for this parameter ($\mu \in \{0.01, 0.5, 0.99\}$).

Figure 1 presents the impulse response for output following a shock to technology under three different rates $\mu \in \{0.01, 0.5, 0.99\}$. At $\mu = 0.01$, the effects of the shock ends after one year, whereas at $\mu = 0.99$, the effects last for (at least) 4 years. A relative difference of 3 years persistence in the business cycle is attributed to this parameter. The relative difference in the depth stands at a 0.5 percentage point of GDP. The Figure illustrates how can one parameter be responsible for the depth-duration trade off. The higher $\mu$ is, the higher is the absorption rate and the lower is the amplitude of the business cycle. The lower is the value of $\mu$, the less persistent is the cycle.

## 5 Extensions

The model proposed here is broad enough to serve as a basis for a multitude of interesting and viable extensions. An immediate extension of the model, is to set the parameter $\mu$ as $\mu_i$ ($i = 1, 2$), where 1 and 2 refer to the degree of shallowness and persistence of the business

cycle, respectively. $\mu_1$ and $\mu_2$ should replace $\mu$ in Equations (2) and (4), respectively. This parametrization implies that the parameter is different in value for the amplitude relative to persistence, but still influenced and determined by the economy structure, i.e., $\mu_i = f(institutions)$. A useful application of such a derivative is to compare the Canadian and the U.S. business cycles. Empirical facts reported here (in Section 3) suggest that $\mu_1^{CAD} \simeq \mu_1^{U.S.}$, and $\mu_2^{CAD} > \mu_2^{U.S.}$, in the sense that both economies share the same amplitude, but the Canadian business cycle will persist more relative to the U.S.

Future research could address the endogeneity of the parameter $\mu$ and more specifically, the speed at which economic reforms cause changes in this parameter. Each economy possesses an institutional characteristic that is specific and heterogeneous to the other economies. Within each economy, this characteristic is time variant [10] and policy/regulations dependent, formally, $\mu_{it} = f(institutions_t)$.

## 6 Conclusions

In this paper, I presented a formulation wherein an economy-specific characteristic - labeled as the missing parameter - (e.g., the financial institutional framework and regulations) does control the magnitude, severity and persistence of the business cycle. This formulation could be perceived as a return to the Institutionalist School. It emphasizes the role of institutions in economic life and advocates that financial institutions can mitigate the sharp swings of

[10] The issue of time-varying structure is proving promising in explaining business cycle characteristics. See Chari, Kehoe and McGrattan (2003) and Ferrero (2003) wherein a prototype growth model with time-varying wedges were proposed.

the business cycle. However, unlike the old-institutionalists, this model does not condemn laissez-faire, but embraces it. Also, the model implicitly provides a role for an exogenous process (e.g., the government) to revise the role of its financial institutions.

Conditioned on the calibrated parameters, the simulation results suggest that an economy-specific parameter is suspect for the depth-duration trade off that is observed over time within and across countries. As much as 0.5 of a percentage point of GDP in depth and a relative difference of 3 years duration can be attributed to this parameter.

The results give rise to a host of questions. Of main concern, how immune is the standard RBC model to the Lucas' critique? If a policy that induces an institutional shift/transition across economic regimes results in changing this parameter, wouldn't the simulated welfare impact (gains/losses) from that policy be inaccurate if based on the 'rigid' assumption of a non-institutional varying impulse?

## References


[1] Acemoglu, Daron, Simon Johnson, James Robinson and Yunyong Thaicharoen. 2003. "Institutional Causes, Macroeconomic Symptoms: Volatility, Crises and Growth," *Journal of Monetary Economics* 50 (1): 49-123.

[2] Ambler, Steve, Emanuela Cardia and Christian Zimmermann. 2004. "International Business Cycles: What Are the Facts?" *Journal of Monetary Economics* 51 (2): 257-276

[3] Artis, Michael, Fabio Canova, Jordi Gali, Francesco Giavazzi, Richard Portes, Lucrezia Reichlin, Harald Uhlig, and Philippe Weil. 2003. "Euro Area Business Cycle Dating Committee of the Centre for Economic Policy Research," Centre for Economic Policy Research, <http://www.cepr.org/press/dating.pdf>.

[4] Artis, Michael J., Z. G. Kontolemis, and D. R. Osborn. 1997. "Business Cycles for G7 and European Countries." *Journal of Business* 70: 249-279.

[5] Artis, Michael J., and W. Zhang. 1999. "Further Evidence on the International Business Cycle and the ERM: Is there a European Business Cycle?" *Oxford Economic Papers* 51: 120-132.

[6] Artis, Michael J., and W. Zhang. 1997., "International Business Cycles and the ERM: Is there a European Business Cycle." *International Journal of Finance and Economics* 2: 1-16.

[7] Blanchard, Olivier, and John Simon. 2001. "The Long and Large Decline in U.S. Output Volatility." *Brookings Papers on Economic Activity* 1: 135-164.

[8] Blomberg, Brock S., and Gregory D. Hess. 2002. "The Temporal Links between Conflict and Economic Activity." *Journal of Conflict Resolution* 46 (1): 74-90.

[9] Carvalho, Vasco, and Andrew Harvey. 2002. "Convergence and Cycles in the Euro-Zone." Working Paper, University of Cambridge, <http://eabcn.org/madrid/carvalho_harvey.pdf>.

[10] Chari, V. V., and Patrick J. Kehoe, Ellen R. McGrattan. 2003. "Business Cycle Accounting." Research Department Working Paper 625, Federal Reserve Bank of Minneapolis, <http://minneapolisfed.org/research/wp/wp625.pdf>.

[11] Clark, T., and K. Shin. 2000. "The Sources of Fluctuations Within and Across Countries." in Gregory D. Hess, and Eric van Wincoop (Eds.), *Intranational Macroeconomics*, Cambridge, U.K.: Cambridge University Press.

[12] Dalsgaard, T., J. Elmeskov, and C-Y Park. 2002. "Ongoing Changes in the Business Cycle – Evidence and Causes." OECD Economics Department, Working Paper no 315.

[13] Del Negro, Marco, and Christopher Otrok. 2003. "Time-Varying European Business Cycles." Working Paper, Department of Economics, University of Virginia.

[14] van Dijk, D., D. R. Osborn, and M. Sensier. 2002. "Changes in the Variability of the Business Cycle in the G7 Countries." Working Paper, Erasmus University Rotterdam.

[15] Djankov, Simeon., Edward L. Glaeser, Rafael La Porta, Florencio Lopez-de-Silanes, and Andrei Shleifer. 2003. "The New Comparative Economics." Working Paper No. 9608, National Bureau of Economic Research, <http://papers.nber.org/papers/w9608.pdf>.

[16] Doyle, B., and J. Faust. 2002a. "An Investigation of Co-movements among the Growth Rates of the G-7 Countries." Federal Reserve Board Bulletin, (October): 427-437.

[17] Doyle, B., and J. Faust. 2002b. "Breaks in the Variability and Co-Movement of G-7 Economic Growth." manuscript, Federal Reserve Board.

[18] Edwards, Sebastien. 2003. "Review of Joseph E. Stiglitz's Globalization and its Discontents." *Journal of Development Economics* 70: 252-257.

[19] Edwards, Sebastien. 2000. "Contagion." World Economy 23: 873-900.

[20] Edwards, Sebastien, Javier Gomez Biscarri, and Fernando Perez de Gracia. 2003. "Stock Market Cycles, Financial Liberalization and Volatility." Working Paper 9817, National Bureau of Economic Research <http://www.nber.org/papers/w9817>.

[21] Farr, W. Ken, Richard A. Lord, and Larry J. Wolfenbarger. 1998. "Economic Freedom, Political Freedom and Economic Well-Being: A Causality Analysis." *Cato Journal* 18 (2): 247-263.

[22] Ferrero, Andrea. 2003. "The Investment Wedge and Business Cycle." Working Paper, New York University <http://homepages.nyu.edu/˜apf210/research/wedges.pdf>.

[23] Frisch, Ragnar Anton Kittil. 1933. *Propagation Problems and Impulse problems in Dynamic Economics*. In Economic Essays in Honour of Gustav Cassel, London: Allen & Unwin Inc.

[24] Fritsche, Ulrich, and Vladimir Kouzine. 2003. "Declining Output Volatility and Monetary Policy in Germany." manuscript, German Institute for Economic Research (DIW Berlin).

[25] Harding, Don and Adrian Pagan. 2002. "Dissecting the Cycle: a Methodological Investigation." *Journal of Monetary Economics* 49 (2): 365-381

[26] Hartley, James E. 1997. *The Representative Agent in Macroeconomics*. Routledge Frontiers of Political Economy, New York: Routledge.

[27] Heathcoate, J., and F. Perri. 2002. "Financial Globalization and Real Regionalization." Working Paper No 9292, National Bureau of Economic Research, <http://papers.nber.org/papers/w9292.pdf>.

[28] Helbling, Thomas F., and Bayoumi, Tamim A. 2003. "Are They All in the Same Boat? The 2000-2001 Growth Slowdown and the G-& Business Cycle Linkages." Working Paper, Research Department, International Monetary Fund, <http://www.imf.org/external/pubs/ft/wp/2003/wp0346.pdf>.

[29] Helg, R., P. Manasse, T. Monacelli, and R. Roveli. 1995. "How Much (A)symmetry in Europe? Evidence from Industrial Sectors." *European Economic Review* 39: 1017-1041.

[30] Hoover, Kevin D. 1995. "Facts and Artifacts: Calibration and the Empirical Assessment of Real-Business-Cycle Models." *Oxford Economic Papers* 47: 24-44.

[31] Kim, C. J., and C. R. Nelson. 1999. "Has the U.S. Economy Become More Stable? A Bayesian Approach Based on a Markov-Switching Model of the Business Cycle." *The Review of Economics and Statistics* 81: 608-616.

[32] Kose, Ayhan, Eswar S. Prasad, and Marco E. Terrones Silva. 2003. "How Does Globalization Affect the Synchronization of Business Cycles?" International Monetary Fund Discussion Paper no. 03/27 <http://www.imf.org/external/pubs/ft/wp/2003/wp0327.pdf>.

[33] Kydland, Finn E., and Edward C. Prescott. 1982. "Time to Build and Aggregate Fluctuations." *Econometrica* 50 (6): 1345-1370.

[34] Luginbuhl, Rob, and Siem Jan Koopman. 2003. "Convergence in European GDP Series." Tinbergen Institute Discussion Paper 03-031/4 <http://www.tinbergen.nl/discussionpapers/03031.pdf>.

[35] Manuelli, Rodolfo and Thomas J. Sargent. 1988. "Models of Business Cycles: A Review Essay." *Journal of Monetary Economics* 22 (3): 523-542.

[36] McConnell, M. M., and G. Perez-Quiros. 2000. "Output Fluctuations in the United States: What has Changed Since the Early 1980's." *American Economic Review* 90 (5): 1464-1476.

[37] Mikhail, Ossama. 2003. "Economic Reforms and the Business Cycle: The Egyptian Experience." Economics Working Paper Archive at WUSTL, 0402002, <http://econwpa.wustl.edu:80/eps/mac/papers/0402/0402002.pdf>.

[38] Mills, Terence C., and Ping Wang. 2002. "Plucking Models of Business Cycle Fluctuations: Evidence From the G-7 Countries." *Empirical Economics* 27: 255-276.

[39] Morgan, Donald, Bertrand Rime, and Philip Strahan. 2003. "Bank Integration and State Business Cycles." Working Paper No. 9704, National Bureau of Economic Research, <http://www.nber.org/papers/w9704>.

[40] Morgan, Mary S. 1995. *The History of Econometric Ideas*. Oxford: Cambridge University Press.

[41] Prescott, Edward C. 1986. "Theory Ahead of Business Cycle Measurement." *Carnegie-Rochester Conference series on Public Policy* 25: 11-24. Also in, Federal Reserve Bank of Minneapolis Quarterly Review 10 (Fall): 9-22.

[42] Quah, Danny T. 1995. "Business Cycle Empirics: Calibration and Estimation." *The Economic Journal* 105: 1594-1596.

[43] Ramsey, James B., and Philip Rothman. 1996. "Time Irreversibility and Business Cycle Asymmetry." *Journal of Money, Credit and Banking* 28 (1): 1-21.

[44] Sharpe, Andrew. 1999. "The Nature and Causes of Unemployment in Canada." in *Employment Policy Options*. Chapter 1, Edited by Ken Battle and Sherri Torjman, The Caledon Institute of Social Policy, <http://www.caledoninst.org>.

[45] Sheffrin, Steven M. 1988. "Have Economic Fluctuations Been Dampened? A Look at Evidence Outside the United States." *Journal of Monetary Economics* 21 (1): 73-83.

[46] Simon, John. 2001. "The Decline in Australian Output Volatility." Reserve Bank of Australia, Reserve Discussion Papers, RDP2001-01, <http://www.rba.gov.au/rdp/RDP2001-01.pdf>.

[47] Stiglitz, Joseph. 2002. *Globalization and its Discontents*. New York: Norton.

[48] Stock, James H., and Mark W. Watson. 2003. "Understanding Changes in International Business Cycle Dynamics." Working Paper No. 9859, National Bureau of Economic Research, <http://www.nber.org/papers/w9859>.

[49] Stock, James H., and Mark W. Watson. 2002. "Has the Business Cycle Changed and Why?" National Bureau of Economic Research Macroeconomics Annual.

[50] Zarnowitz, Victor. 1985. "Recent Work on Business Cycles in Historical Perspective: A Review of Theories and Evidence." *Journal of Economic Literature* 23 (2): 523-580.

# 7 Appendix (not for publication)

Write the log-linearized system as,

$$\begin{aligned} 0 &= Ax_t + Bx_{t-1} + Cy_t + Dz_t \\ 0 &= E_t\left[Fx_{t+1} + Gx_t + Hx_{t-1} + Jy_{t+1} + Ky_t + Lz_{t+1} + Mz_t\right] \\ z_{t+1} &= Nz_t + \epsilon_{t+1} \qquad\qquad E_t\left[\epsilon_{t+1}\right] = 0 \end{aligned}$$

where $x_t$ denotes the state vector, $y_t$ refers to the jump variables and $z_t$ refers to the exogenous ones. It is assumed that $N$ has only stable eigenvalues. Using Theorem 3.2 in Uhlig (2001, p. 38), we solve for the recursive equilibrium law of motion

$$\begin{aligned} x_t &= Px_{t-1} + Qz_t \\ y_t &= Rx_{t-1} + Sz_t \end{aligned}$$

To compute the $P, Q, R$ and $S$ matrices, we solve,

$$\begin{aligned} 0 &= C^0AP + C^0B \\ 0 &= (F - JC^+A)P^2 - (JC^+B - G + KC^+A)P - KC^+B + H \\ R &= -C^+(AP + B) \\ V &= \begin{bmatrix} I_k \otimes A & I_k \otimes C \\ N' \otimes F + I_k \otimes (FP + JR + G) & N' \otimes J + I_k \otimes K \end{bmatrix} \\ V\begin{bmatrix} vec(Q) \\ vec(S) \end{bmatrix} &= -\begin{bmatrix} vec(D) \\ vec(LN + M) \end{bmatrix} \end{aligned}$$

given that all eigenvalues of $P$ are less than unity in absolute value. We choose the root(s) manually. $C^+$ denotes the pseudo-inverse of $C$. $C^+ = (C'C)^{-1}C'$. $C^0 \equiv (null(C'))'$. The $C^0$ is found by singular value decomposition of $C'$. Note that $C^0C = 0$.

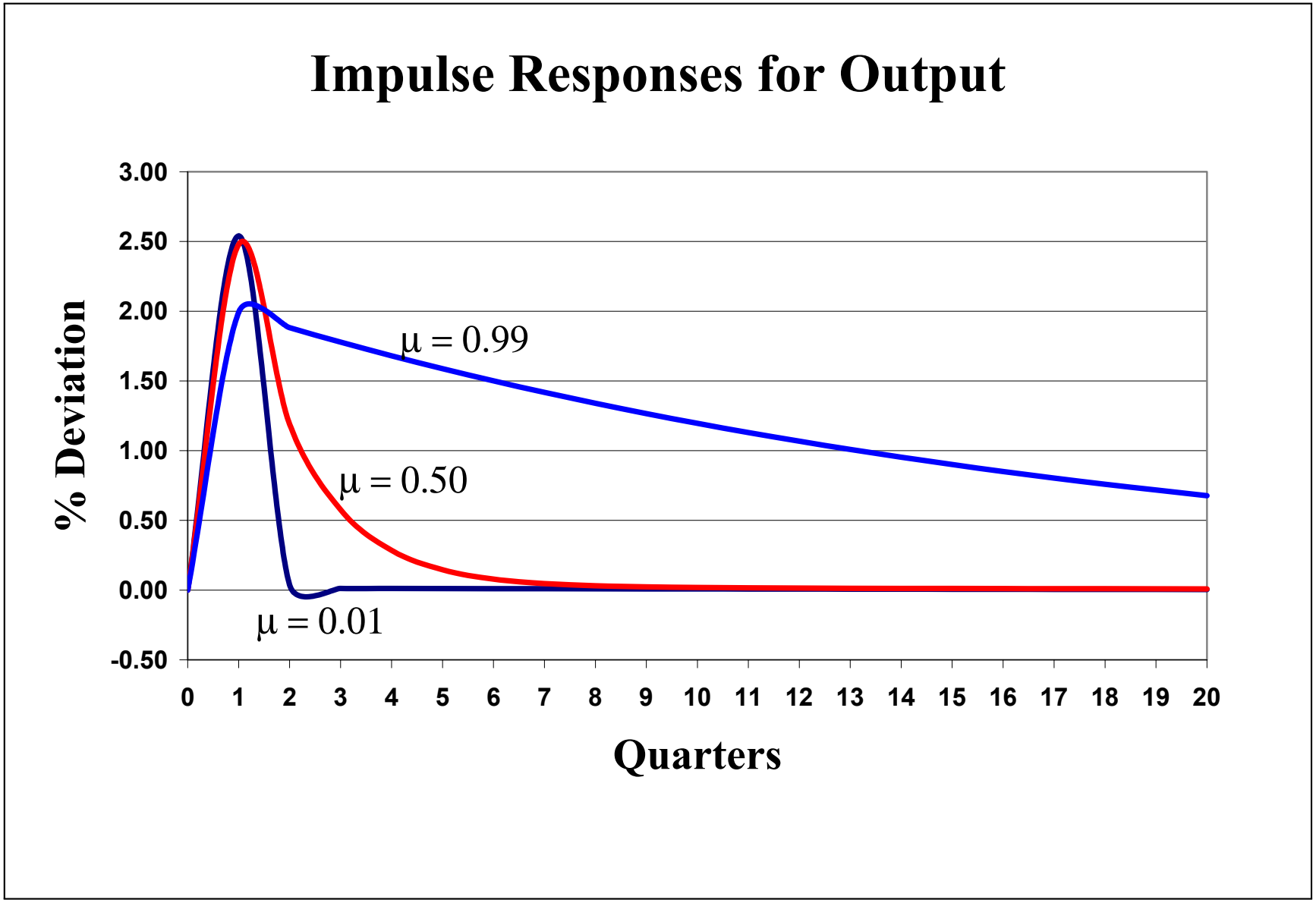


Figure 1. Impulse Responses for Output - $\mu \in \{0.01, 0.5, 0.99\}$