Eigenvalue Elasticity Analysis

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This document provides the answers to the questions posed in the challenge section of the *Eigenvalue Elasticity Analysis* chapter and describes a strategy on how the EEA tools could be used to address them.

Loops 17 and 24 are the only loops that contain the interest rate (R) that are active in the base case. What is the role of these loops in that base run? What behavior modes do they affect?

From Table 3 and Figure 4 in the chapter we see that loop 17 links the aggregate demand (AY) stock to capital (K) through the effect of the interest rate (R) on capital investment. Capital affects the aggregated demand, and the interest rate is adjusted to balance that aggregate demand for goods and services with the current price level (P) and the monetary supply (M).

Looking at the model equations we see that the capital investment drops from its desired level if the interest rate increases, i.e., if the cost of capital is higher, and that an aggregate demand above its equilibrium value will increase the interest rate. Thus, the loop is a balancing loop that regulates capital investment. Note that in the base case the interest rate is not affected by monetary supply.

Using the LEEA utility (nf_base_LEEA.nb) we see that loop 17 is not very influential in most eigenvalue. The only eigenvalue in which it shows among the 10 most influential loops is eigenvalue 6—an exponential decay with time constant of 2.5 years—in which it plays a marginal stabilizing effect. Checking the gains table in the LEEA utilities confirms this as we see that the loop has a very small gain (-0.003) relative to the most dominant loops in the model structure, –16.00 and –4.68 for loops 7 and 18 respectively.

Loop 24 is balancing loop that links the employment, price, capital, and long-term expected demand stocks. The role of the interest rate in this loop is also to adjust the capital investment, but in this case is the response to the deviations of the price stock relative to its equilibrium value. If the economy overheats and capital (K) and employment (EMP) go over its long term equilibrium values, unemployment drops, thus increasing prices (inflation), and bringing pressure to increase the interest rate.

Using the LEEA utility we see that loop 24 has the sixth greatest gain (-0.415), albeit a small fraction of the strongest loops, and that is has a destabilizing impact on eigenvalues {3,4}, the business cycle. Loop 24 also has a marginally stabilizing effect on eigenvalue 2—a fast exponential decay with time constant of about 4 months, related to the time to adjust short-term employment.

How does the role of R change in the full model? What behavior models is it affecting?

The role of loops 17 and 24 does not change, however, now the interest rate is also plays a role on loops 19, 20 and 21, that were not active in the base case simulation. These three loops adjust the monetary supply (M) to pressures from desired employment and actual employment. Loops 20 and 21 reflect the inputs to the policy trigger (PT), employment relative to desired employment, to activate the adjustment of the monetary supply (RCM), and loop 21 sets the target monetary supply (TMS).

The role of the interest rate (R) continues to be to adjust the capital investment, but now it responds also to the monetary supply, that is affected by policy. Checking the gain of the loops, we see that the gain of loops 17 and 24 has not changed, and that gain of the added loops is negligible (reported at 0 under three significant digits).

In the analysis of the full model we had identified loop 8, the first-order control of monetary supply (M), as the most influential loop for this behavior mode (period of 5.96 years). The output of this loop (M) has a direct impact on the interest rate and its rate of adjustment is determined by the feedback loops just activated that work through the interest rate {19,20,21}. Note that the LEEA calculations concentrated all the influence in the monetary adjustment rate (loop 8), where the gain was significant, and loops 21 and 19 are relinquished to 5th and 10th place respectively. While this might be perceived as a shortcoming of the output generated by the LEEA utility, this is just the result of the line of inquired pursued here. Keep in mind that if we had entered this analysis to find levers to modify eigenvalue, we would have identified loop 8, and then the set of loops that work through interest rate.

What parameter changes (policies) would you introduce to augment (diminish) the impact of the interest rate (R) on the business cycle? On the capital cycle?

This question is a bit tricky since the interest rate (R) is not a stock, thus the DDWA utility does not report directly the impact of R. Instead, we need to explore the effect of R on the stocks that affect the reference mode of interest.

Business Cycle

From Figure 11 in the chapter, we know that the business cycle is mainly influenced by three first-order loops for short-term expected demand, employment and unemployment (loops 11, 2, and 7), a second order loop between inventory (IV) and short-term expected demand (SED) (loop 13), and the main destabilizing loop is a third-order loop (18) including inventory (IV), short-term expected demand (SED) and employment (EMP). None of the loops that include the interest rate include the inventory stock. However, note that loop 20 includes, in addition to the interest rate, the stocks for short-term expected demand (SED) and employment (EMP). In fact, SED is involved in 4 of the loops in the SILS that go through the interest rate (R).

Checking on the DDWA utility the parameter elasticity for eigenvalue (behavior mode) 1 on the EMP and SED stocks we see that, in addition to two scaling parameters (eyvm, ep) the three most influential parameters are time to smooth unemployment (tsu), time to adjust employment (tae), and time to adjust monetary supply (tam). All these parameters affect also the gain of loops 20 and 21, and as such, would have the largest impact on the desired reference mode through their impact on the interest rate. The sign of the elasticity gives the direction of the adjustment.

Capital Cycle

From Figure 12 in the chapter, we know that the capital cycle is mainly controlled by the first order loops for capital depreciation and the short- and long-term expectations for demand, i.e., first order control loops for stocks K, SED and LED, and the second order loop involving the SED and the permanent income (PY) stock (loop 25). Again, the SED stock is at influenced by four loops that contain the interest rate (R).

Checking on the DDWA utility the parameter elasticity for eigenvalue (behavior mode) 4 on the SED stock we see that, in addition to one scaling parameter (ee), the most influential parameters are the time constants for the formation of expected demand (tssd and tsld) and the time to adjust inventory.

This sequence of exploration reveals a particular strength of the EEA tools. We initiated the exploration attempting to mitigate (or augment) the role of the interest rate on a particular behavior mode. This strategy would traditionally have lead to assess the impact of the parameters that either affect the role of R on its dependents (e.g., alpha and alk on desired capital), or the parameters that define the responsiveness of R to the feedback from its antecedents (e.g., iem and yem on interest rate). However, by taking a integrated system perspective of all the feedback mechanisms that affect the model behavior we were able to identified parameters within the feedback loops through which the interest rate operates that have stronger influence in the system behavior.