Withering Government Spending Multipliers

The empirical literature has documented a weakening of the consumption and output responses to an increase in government spending during the last 30 years. We show that a New Keynesian model in which real government spending is observed with measurement errors can account for the reduction in the size of government spending multipliers. The model implies—consistent with empirical evidence presented by Ilzetzki, Mendoza, and Vegh (2010)—that the evolution of monetary policy and greater globalization (increasing international trade and decreasing capital controls) are key factors in this development.

**JEL codes:** E32, E62, F39

**Keywords:** government spending multiplier, monetary policy, openness, imperfect information.

The response of consumption to an unanticipated increase in government spending has weakened over the last 30 years in most Organisation of Economic Co-operation and Development (OECD) countries, and output multipliers have also fallen. Perotti (2004), Monacelli and Perotti (2006), and Ravn, Schmitt-Grohe, and Uribe (2012) show that there was a structural break around 1980 in the U.S., the UK, Germany, Canada, and Australia. Pre-1980, the response of consumption was positive, while post-1980 it is near zero. Similarly, pre-1980 output multipliers were positive and, at least in the U.S., greater than one; post-1980, they are near zero. As far as we are aware, there has been no rigorous attempt to model the evolution of government spending multipliers and to identify the factors that were important in their withering. That is our objective in this paper.

We thank Morten Ravn as well as two anonymous referees for valuable comments and suggestions.

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Received December 19, 2011; and accepted in revised form July 30, 2012.

Journal of Money, Credit and Banking, Supplement to Vol. 44, No. 2 (December 2012) © 2012 The Ohio State University
More specifically, we build a new open economy macroeconomic (NOEM) model and study two calibrations of it: one to pre-1980 (Canadian) data and the other to post-1980 data. These two calibrations are able to explain the observed evolution of consumption responses and output multipliers. Our model suggests that the most important factor was the evolution of monetary policy, in which the stabilization of exchange rates gave way to a standard Taylor rule.\textsuperscript{1} Globalization (in the form of increased openness, and to a lesser extent, the relaxation of capital controls) also played a role. A more stable government spending process was not a factor.\textsuperscript{2} Our findings concerning the role played by monetary policy (exchange rate regime) and the degree of openness fit well the empirical evidence presented by Ilzetzki, Mendoza, and Vegh (2010).\textsuperscript{3}

As is well known, it is difficult to build a (so-called) New Keynesian model in which households increase their consumption in response to an unanticipated increase in government spending. The old Keynesian notion was that disaggregated households increased their spending in response to the income generated by the increased spending of others; this sequential process led to what became known as the Keynesian multiplier. In modern dynamic stochastic general equilibrium (DSGE) models, assumptions about consumption risk sharing lead to a representative consumer, and this representative consumer sees the increase in government spending as a tax liability, or a decrease in permanent income; the representative consumer wants to work more and consume less. This response is counterfactual, at least for the pre-1980 period, and indeed, we find that our model cannot explain the evolution of output multipliers unless something is added to get around this negative wealth effect.

The most popular way of getting around the negative wealth effect is to model rule of thumb households—households that, for one reason or another, simply consume their current disposable income. This idea may be reminiscent of earlier Keynesian notions, but in calibration exercises, a very large fraction of total consumption must be attributed to the rule of thumb if this kind of modeling is to fit the data (see, e.g., Coenen and Straub 2005, Erceg, Guerrieri, and Gust 2006, Galí, López-Salido, and Valles 2007).

1. There is a well-documented change in monetary policies that began around 1980 in most OECD countries. The demise of the Bretton Woods system occurred somewhat earlier. The Canada/U.S. exchange rate appears to have gotten more volatile around 1977 (the standard deviation of quarterly percentage changes in the 1977–2008 sample is about three times larger than in the 1960–76 sample). Since the literature on government spending multipliers puts the break at 1980, and the literature on monetary policy also puts the break at 1980, we have chosen that date for our break in our two calibrations of the model.

2. Parallel to the moderation of the effects of fiscal policy, there has been a widely documented moderation in the severity of the business cycle. Whether the fiscal moderation has contributed significantly to the total moderation or not remains an open issue. Fiscal shocks are rather unimportant for business cycles in the New Keynesian model.

3. In particular Ilzetzki, Mendoza, and Vegh (2010) find that the degree of exchange rate flexibility is a critical determinant of the size of fiscal multipliers. Economies operating under predetermined exchange rate regimes have positive multipliers but economies with flexible exchange rate regimes have essentially zero multipliers. They also find that the degree of trade openness is also an important determinant.
We have chosen a different approach, which follows Lucas' (1972) suggestion that economic agents may face imperfect information about macroeconomic (and possibly microeconomic, or idiosyncratic) shocks. In our case, they see their income rising, following an unanticipated government spending shock, but they are not sure why. Their perceptions are confounded by the possibility of other shocks that would actually increase their permanent income. As will be seen, a rather small amount of noise in agents' observations is sufficient in our calibrations to make household consumption (and investment) respond positively to the fiscal shock.

And indeed, imperfect information and learning provide the fulcrum in our model for a Mundell–Flemming effect that plays an important role in what follows. With imperfect information, a government spending shock increases consumption and investment. Due to home bias, this increase in aggregate demand puts upward pressure on the relative price of home goods. In a fixed exchange rate regime, the central bank must conduct expansionary open market operations to keep the nominal exchange rate from appreciating. This policy slows the rise in the relative price of home goods and keeps it from curbing the increase in aggregate demand; government spending multipliers are large. In a flexible exchange rate regime, there is no direct concern about the change in the nominal exchange rate, only for its indirect effects on domestic prices. For standard calibrations of the model, monetary policy is less accommodative under a flexible regime, leading to smaller multipliers. This is a familiar story. However, the point here is that the Mundell–Flemming effect is never set in motion in a standard NOEM without imperfect information: consumption must rise following the increase in government spending if the flexibility of the exchange rate is to matter for output multipliers.

A related observation is that a perfectly observed (or fully anticipated) increase in government spending will not increase consumption in our model, and this fact may be consistent with a different branch of the literature on government spending multipliers. The event study approach used by Ramey and Shapiro (1998) and others typically finds that easily identified episodes of large increases in defense spending cause output to increase, but private consumption to fall. Once again, imperfect information is required in our model if consumption is to rise in response to an increase in government spending.

The rest of the paper proceeds as follows. In Section 1, we outline our model and our calibration of a pre-1980 benchmark and a post-1980 benchmark. In Section 2, we show that the two benchmarks are able to explain the evolution of government

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4. Recently, Perotti and Monacelli (2006) and Ravn, Schmitt-Grohe, and Uribe (2012) suggest other explanations: nonseparable utility and deep habits. It is too early to tell whether these alternative explanations will gain traction.

5. Using the Real Time Data Set of the Philadelphia FED for the U.S. we establish that the measurement error in real government expenditure in the U.S. is quite substantial. And that the amount of misperception in real public spending required by the model is considerably smaller than that present in real time releases of U.S. public spending data.

6. In contrast to empirical work investigating the response of consumption, there is little work on the response of investment to government spending shocks. Fatas and Mihov (2003) find a weak but positive response.
spending multipliers (and the weakening of consumption responses) that has been observed in the data. Since the change in monetary policy plays an important role in the model’s explanation of this evolution, we also calculate the multipliers under some other monetary policies—a fixed money growth rule and a strict inflation targeting rule. The money growth rule was the alternative to a fixed exchange rate regime in the Mundell–Flemming paradigm, and a strict inflation targeting rule may be the direction in which many central banks in the OECD are headed. Section 3 concludes with some caveats and directions for future research.

1. THE MODEL

The model consists of a small domestic economy and a large foreign economy (or rest of the world). The domestic economy is characterized by monopolistic competition and Calvo price setting, competitive labor markets and flexible wage rates, endogenous capital accumulation, and imperfect information about macroeconomic shocks. The household’s signal extraction problem causes its consumption to rise in response to an unanticipated increase in government spending.

1.1 Production of the Domestic Final Goods

The domestic final goods, \( y \), can be used for domestic consumption (private and public) or for investment. Competitive firms produce this final goods by combining domestic (\( x_d \)) and foreign (\( x_f \)) goods. A constant elasticity of substitution (CES) aggregator describes their production function

\[
y_t = (\omega^{1-\rho} x_{d,t}^\rho + (1 - \omega)^{1-\rho} x_{f,t}^\rho)^{\frac{1}{\rho}},
\]

where \( \omega \in (0, 1) \) and \( \rho \in (-\infty, 1) \).

Cost minimization by the final goods producers implies the demand functions

\[
x_{d,t} = \left( \frac{P_{at}^*}{P_t} \right)^{\frac{1}{\rho-1}} \omega y_t, \tag{2}
\]

\[
x_{f,t} = \left( \frac{e_i P_{at}^*}{P_t} \right)^{\frac{1}{\rho-1}} (1 - \omega) y_t, \tag{3}
\]

where \( P_{at}^* \) and \( e_i P_{at}^* \) denote the home currency price of the domestic and the foreign goods. The price of the final goods is

\[
P_t = \left( \omega P_{at}^* + (1 - \omega)(e_i P_{at}^*)^{\frac{\rho}{\rho-1}} \right)^{\frac{\rho-1}{\rho}}. \tag{4}
\]
Competitive firms produce $x_t = x_{d,t} + x^*_d, t$ (and $x^*_t$ abroad) by combining domestic and foreign intermediate goods

$$x_t = \left( \int_0^1 x_{d,t} (i)^\theta \, di \right)^{\frac{1}{\theta}},$$

(5)

where $\theta \in (-\infty, 1)$. And again, cost minimization give the demand for intermediate goods

$$x_{d,t}(i) = \left( \frac{P_{xt}(i)}{P_{xt}} \right)^{\frac{1}{\theta_1}} x_{d,t}.$$

(6)

Similarly, the domestic demand for the foreign intermediate goods $i$ is given by

$$x_{f,t}(i) = \left( \frac{P^*_xt(i)}{P^*_xt} \right)^{\frac{1}{\theta_1}} x_{f,t},$$

(7)

where

$$P_{xt} = \left( \int_0^1 P_{xt}(i)^{\frac{\theta_1 - 1}{\theta_1}} \, di \right)^{\frac{\theta_1 - 1}{\theta_1}}, \quad P^*_{xt} = \left( \int_0^1 P^*_xt(i)^{\frac{\theta_1 - 1}{\theta_1}} \, di \right)^{\frac{\theta_1 - 1}{\theta_1}}.$$

(8)

1.2 Production of the Domestic Intermediate Goods

Each intermediate firm $i$, $i \in (0, 1)$, uses a constant returns to scale technology

$$x_t(i) \leq A_t \tilde{k}_t(i)^{\alpha} h_t(i)^{1-\alpha} \text{ with } \alpha \in (0, 1),$$

(9)

where $\tilde{k}_t(i)$ and $h_t(i)$ denote capital services\(^7\) and labor. $A_t$ is an exogenous technology shock whose properties will be defined later. Both the capital and the labor market are perfectly competitive; the wage and rental rates, $w_t$ and $r_{k,t}$, are flexible. The firm determines its production plan by minimizing its real cost

$$\min_{[u_{k,i}(i), h_t(i)]} w_t h_t(i) + r_{k,t} u_{k,i}(i)$$

subject to (9). Minimized real total costs are then given by $\psi_t x_t(i)$ where the real marginal cost, $\psi_t$, is given by

$$\psi_t = \frac{r_{k,i}^{\alpha} w_t^{1-\alpha}}{\zeta A_t},$$

with $\zeta = \alpha^\alpha (1 - \alpha)^{1-\alpha}$.  

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7. In an equilibrium, we have that $\tilde{k}_t = \int_0^1 \tilde{k}_t(i) \, di = u_t k_t$, where $u_t$ and $k_t$ denote, respectively, capital utilization rate and the level of the capital stock. As will become clear later, the capital utilization rate will be selected by the household.
Intermediate goods producers are monopolistically competitive and therefore set prices for the goods they produce. Following Calvo (1983), in any given period, a firm gets to adjust its price optimally with probability $\gamma$. If the firm does not get this chance, then its price is automatically indexed to the steady-state rate of inflation, $\bar{\pi}$:

$$P_x(i) = \bar{\pi} P_{x,t-1}(i).$$  \hspace{1cm} (10)

A firm that does get to adjust will set its price at

$$\bar{P}_x(i) = \frac{1}{\theta} \mathbb{E}_t \sum_{\tau=0}^{\infty} (1 - \gamma)^\tau \Phi_{t+\tau} \frac{\bar{\pi} \psi_{t+\tau} y_{t+\tau}}{\Phi_{t+\tau} \phi_{t+\tau} P_{t+\tau}}.$$

where $\Phi_{t+\tau}$ is an appropriate discount factor derived from the household’s optimality conditions. Since the price setting scheme is independent of any firm-specific characteristic, all firms that reset their prices will choose the same price.

In each period, a fraction $\gamma$ of price contracts ends and a fraction $(1 - \gamma)$ survives. Hence, from (8) and the price mechanism, the aggregate price of the domestic goods becomes

$$P_x = (\gamma \bar{P}_x(i))^{\bar{\pi}} + (1 - \gamma)(\bar{\pi} P_{x,t-1}(i))^{\bar{\pi}}.$$  \hspace{1cm} (12)

1.3 The Household

Household utility is

$$\mathbb{E}_t \sum_{\tau=0}^{\infty} \beta^\tau \left[ \log(c_{t+\tau} - bc_{t+\tau-1}) + \frac{\nu^m}{1 - \sigma_m} \left( \frac{M_{t+\tau}}{P_{t+\tau}} \right)^{1-\sigma_m} - \frac{\nu^h}{1 + \sigma_h} h_{t+\tau}^{1+\sigma_h} \right].$$

where $c_t$ denotes consumption of the final good, $M_t/P_t$ is (end-of-period) real money balances held by the household, and $h_t$ is hours worked by the household; $0 < \beta < 1$ is a constant discount factor, and $b$ is a parameter that measures the degree of habit persistence in consumption.

The household’s budget constraint is

$$B_t^D + e_t B_t^F + M_t + P_t(c_t + i_t + z(u_t)k_t + \tau_t) = R_{t-1} B_{t-1}^D$$

$$+ R_{t-1}^* e_t B_{t-1}^F - \frac{\chi}{2} P_t \left( \frac{e_t B_t^F}{P_t} \right)^2 + P_t r_{k,t} u_t k_t + P_t w_t h_t + M_{t-1} + \Pi_t,$$

where $B_t^D$ and $B_t^F$ are domestic and foreign currency bonds, and $\tau_t$ is a lump sum tax used by the government to balance its budget each period. The foreigners do not hold domestic bonds: so, $B_t^D = 0$ in equilibrium. $\frac{\chi}{2} P_t \left( \frac{e_t B_t^F}{P_t} \right)^2$ is an adjustment cost.
on foreign bond holdings; \(i_t\) is household investment; \(k_t\) is the amount of physical capital owned by the household and leased to the firms; and \(u_t\) is the household’s choice of the capital utilization rate. Utilization of the capital gives rise to a utilization cost of \(z(u_t)k_t\), where \(z(\cdot)\) is a convex strictly increasing function, with \(z(\bar{u}) = 0\) and \(z''(\bar{u})\bar{u}/z'(\bar{u}) = \sigma_z\). Households own the domestic firms, and \(\Pi_t\) are their profits. Finally, \(\chi > 0\) measures the strength of capital controls on the household’s holdings of foreign assets.

Capital accumulates according to the law of motion

\[ k_{t+1} = i_t \left( 1 - \Phi \left( \frac{i_t}{i_{t-1}} \right) \right) + (1 - \delta)k_t, \tag{15} \]

where \(\delta \in [0, 1]\) denotes the rate of depreciation. Capital accumulation is subject to increasing and convex investment adjustment costs satisfying \(\Phi(1) = \Phi'(1) = 0\) and \(\Phi''(1) = \varphi_i > 0\).

The household then maximizes (13) subject to (14) and (15).\(^9\)

1.4 Monetary Policy

We will generally characterize monetary policy by an interest rate rule of the form

\[ R_t = \rho_r R_{t-1} + (1 - \rho_r) \left[ \gamma_\pi \pi_t + \gamma_y y_t + \gamma_{\Delta e} \Delta e_t \right], \tag{16} \]

where \(\Delta e_t\) is the rate of depreciation. However, we will also consider the case where the central bank follows a constant money growth rule, \(M_t = (1 + g_m)M_{t-1}\).

1.5 The Rest of the World

We model the foreign economy with an analogous, but stripped down, structure. Foreign demand for the domestic goods is

\[ x^*_d,t = \left( \frac{P_{st}}{e_t P^*_t} \right)^{\frac{1}{\rho_e}} (1 - \omega^* \exp(-\zeta_{out}) y^*_t), \tag{17} \]

where \(\zeta_{out}\) is a preference shock. We do not model investment in the foreign economy; so \(c^*_t = y^*_t\). Both \(y^*_t\) and \(\pi^*_t\) are modeled as exogenous AR(1) processes. Finally, a Euler equation determines the foreign interest rate, \(R^*_t\).

\[ \frac{1}{y^*_t} = \beta R^*_t \mathbb{E}_t \left[ \frac{1}{y^*_{t+1} \pi^*_{t+1}} \right]. \tag{18} \]

\(^9\) First-order conditions are reported in a companion technical appendix available at http://fabcol.free.fr/index.php?page=research.
TABLE 1

PROPERTIES OF MISPERCEIVED CHANGES IN GOVERNMENT EXPENDITURES

| Period          | $g(t|T)$ | $g(t|T) - g(t|t)$ | $g(t|t+1) - g(t|t)$ |
|----------------|---------|------------------|--------------------|
|                | $\sigma_g$ | $\sigma_\mu$ | $\sigma_\mu/\sigma_g$ | $\rho$ | $\sigma_\mu$ | $\sigma_\mu/\sigma_g$ | $\rho$ |
| 1966Q1–2002Q4  | 1.01    | 1.15             | 1.13               | 0.03    | 0.42          | 0.41               | -0.04 |
| 1966Q1–1979Q4  | 1.14    | 1.13             | 0.99               | 0.17    | 0.41          | 0.36               | 0.04  |
| 1980Q1–2002Q4  | 0.91    | 1.11             | 1.22               | -0.16   | 0.41          | 0.45               | -0.15 |

Note: $\sigma_g$ denotes the standard deviation of $g(t|T)$, $\sigma_\mu$ denotes the standard deviation of the measurement error, and $\rho$ is the first-order autocorrelation of the measurement error.

1.6 Imperfect Information and the Signal Extraction Problem

Uncertainty (misperceptions) about the true level of real government spending plays a crucial role in our analysis. It enables the model to generate a positive response of consumption to a positive spending shock and also to capture the size and evolution of multipliers during the last few decades. Before proceeding any further we need to convince the readers that, while information on real government spending is available with a short time lag (one or two quarters), it is ridden with substantial measurement error. To this purpose, and lacking suitable data for Canada, we will use the real time data set of the Philadelphia Federal Reserve Bank (FED)\textsuperscript{10} to compute the measurement error in real U.S. government spending. Given the nature of data collection and processing in the industrial countries, we speculate that the properties of measurement error in real public spending in Canada and the U.S. are likely to be quite similar.

Let $G_{t|t}$ be the initial release of government spending of period $t$ (first reported in vintage $t+1$) and $g_{t|t} = \log G_{t|t} - \log G_{t-1|t}$ its growth rate. Let $G_{t|t+i}$ (resp. $g_{t|t+i} = \log G_{t|t+i} - \log G_{t-1|t+i}$) be the revised figure for period $t$ that is available in period $t+i$, $i > 1$. We use $t+i = T$ to represent the “final” release. The measurement error in real government spending growth in period $t$ is then $\mu_{t|T} = g_{t|T} - g_{t|t}$. As an alternative measure we also report the one-step-ahead revision $\mu_{t|t+1} = g_{t|t+1} - g_{t|t}$.

Table 1 reports the properties (standard deviation and autocorrelation) of the final release of real spending growth and of the associated measurement error.

As can be seen these errors are quite substantial in comparison to the volatility of the actual shock in real government spending (second column of the table), to other shocks and also to the volatility of measurement error in other macroeconomic variables (for the latter see Collard and Dellas 2010). Moreover, they do not display serial correlation. The second block of columns (6–8) of Table 1 reports similar information for $\mu_{t|t+1} = g_{t|t+1} - g_{t|t}$. The size of the standard deviations provides information on the speed of learning. As can be seen, imperfect information is large and persistent. Figure 1, which plots the time evolution of the standard deviation of the measurement error as a function of time, offers further support for this claim.

\textsuperscript{10} The data can be downloaded from http://www.phil.frb.org/research-and-data/real-time-center/real-time-data/.
The concept of unperceived government spending shocks plays a key role in the analysis. But do these measurement errors capture misperceptions? The answer would be affirmative if they could not be predicted on the basis of information that was available at the time of the initial release. The approach of Mankiw et al. (1984) can be used to test for the presence or absence of predictability in these errors. In Table 2, we report the results from a regression of $\mu_t|T$ on values of the federal fund rate ($R$) and changes in the stock market ($\Delta S&P$), as in Mankiw et al. (1984).

As can be seen from the table, and as indicated by the $F$-test (column $F$ of the table), measurement errors cannot be predicted so they represent a good measure of unperceived real government spending.

Having established that real government spending contains a significant misperceived component, we now turn to the discussion of the informational setup of the model. With the exception of financial price variables, all aggregate variables tend to be observed with noise. For an imperfectly observed variable $x$ we assume that

$$x_t = x_t^T + \eta_t,$$

where $x_t^T$ denotes the true value of the variable, $x_t$ is the value actually observed in period $t$ and $\eta_t$ is a measurement error that satisfies $E(\eta_t) = 0$ for all $t$, $E(\eta_t\epsilon_{a,t}) = E(\eta_t\epsilon_{g,t}) = E(\eta_t\epsilon_{\mu,t}) = 0$, and

$$E(\eta_t\eta_k) = \begin{cases} \sigma^2_\eta & \text{if } t = k \\ 0 & \text{otherwise.} \end{cases}$$


12. Note that Table 1 already indicates the absence of autocorrelation and hence of predictability based on own lagged values in $\mu_t|T$. But this is not sufficient to establish the lack of predictability as there may be other variables at the time of the release that could help forecast future government spending.

13. We have also considered additional variables whose values are available at the time of the release. The results remain the same.

14. These results are robust to the introduction of other variables—such as output growth—in the regression. See Table A1 and the companion technical appendix mentioned in footnote 9.
Agents use the Kalman filter to update their beliefs about the state of the economy based on the history of observations \( \{x_t, x_{t-2}, \ldots \} \) as well as their knowledge of the model. The solution is described in some detail in a technical appendix to Collard, Dellas, and Smets (2009).

There exist many possibilities and a great deal of arbitrariness in specifying the details of the signal extraction problem. This is because the variables are linked through the equations of the model and the size of the system (and hence the number of variables) can be arbitrarily reduced through successive substitutions (see Svensson and Woodford 2003). In general, there exist many different specifications of the information structure (the distribution of signals across variables) that lead to similar results. The structure we chose—while arbitrary—satisfies the following weak requirements. First, the signal extraction problem is meaningful. That is, the information available does not allow the agents to infer the true values of the variables. Second, financial prices, namely, the nominal exchange rate and the nominal interest rate, are perfectly observed. Third, inflation and output are directly but imperfectly observed. This implies that the other aggregate variables are also imperfectly observed but indirectly (i.e., through the solution of the model, which the agents can execute). And fourth, the amount of misperception implied by the model regarding the key variable, namely, real government spending, does not exceed that implied

<table>
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<tr>
<th>Year</th>
<th>Cst.</th>
<th>( R_t )</th>
<th>( \Delta S&amp;P )</th>
<th>( F )</th>
<th>D.W.</th>
<th>( R^2 )</th>
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<tr>
<td></td>
<td>0.001</td>
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<td>2.69</td>
<td>2.34</td>
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<tr>
<td></td>
<td>(0.001)</td>
<td></td>
<td>(0.015)</td>
<td>[0.105]</td>
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</tr>
</tbody>
</table>

Note: \( R = \) federal fund rate, \( \Delta S&P = \) changes in the S&P stock market index. Standard deviations in parentheses. \( F \) denotes the joint significance test of the regressors, the corresponding \( p \)-value is in brackets.
by the measurement error in the U.S. data. The last requirement guarantees that the results do not hinge on excessively large informational frictions.

We estimate a nonconstrained version of equation (19)—\( x_t = \alpha_0 + \alpha_1 x_{t-1} + \eta_t \)— for GDP and inflation in the U.S. using the Philadelphia FED Real Time Data Set and test for the error in variable assumption. This test amounts to test the joint restriction \( \alpha_0 = 0 \) and \( \alpha_1 = 1 \). The results for the test are reported in the first column of the table. We then use the standard error of these regressions (reported in the second column) as our measure of \( \sigma_{\eta}^2 \) for \( y \) (and \( y^* \)) and \( \pi \) (and \( \pi^* \)), respectively. Results for the whole period are reported in Table 3.

The error in variables test indicates that the null hypothesis that \( \eta_t \) is indeed a mispecification error cannot be rejected in the data. The table also indicates that both output and inflation are both significantly affected by misspecification errors. Again the hope is that these numbers do not differ much from their Canadian counterparts.

1.7 Parameterization

We parameterize our model using quarterly Canadian data for the period 1962Q1 to 2003Q4.\(^{15}\) We will have two benchmark calibrations: the benchmark fixed rate (or Bfixed) calibration for the pre-1980 period and the benchmark flexible rate (or Bflex) calibration for the post-1980 period. This terminology is somewhat inappropriate, since the emphasis on exchange rate stabilization waned in the mid-1970s. However, the language highlights a prominent difference between the two periods, and one that will be important in what follows. The parameters for the two benchmark calibrations are reported in Table 4; where the other parameters differ in the two calibrations, the first number is for Bfixed and the second is for Bflex. In the Bfixed calibration, monetary policy fixes the nominal exchange rate; in the Bflex calibration, monetary policy is governed by an estimated Taylor rule.

We set the preference parameters at values that are commonly used in the business cycle literature. We set \( \beta \), the discount factor, so that households discount the future at a 4% annual rate. We set \( \sigma_m \), the inverse of the elasticity of money demand, at 1.5. We let \( \sigma_h \), the inverse of the Frisch labor supply elasticity, be equal to 1. We set \( \psi_h \) so

15. The data were taken from the OECD’s main economic indicators.
that households devote 30% of their time to productive activities in the steady state. And finally, we set $b$, the habit persistence parameter, at 0.65.

On the supply side, we set $\theta$ so that there is a 20% price markup (over marginal cost) in the steady state. The technology parameter $\alpha$ is set so that the labor share is 0.58 in the steady state. We set $\sigma_z$, the elasticity parameter in the capital utilization cost to 0.1. The Calvo parameter insures that firms reset their prices every 2.5 quarters on average.
We set $\rho$ so that the elasticity of substitution between the foreign and domestic good is equal to 1.5; $\omega$ is then used to match the historical import shares during the two benchmark calibrations: 20% for the pre-1980 period and 28%, for the post-1980 period. We set the corresponding parameter for the world economy at 0.99, implying that Canadian exports are 1% of the world economy’s consumption. Based on Canadian and world GDP data, we assume that the world economy is about 30 times bigger than the Canadian economy. We follow Dib (2011) and set the parameter, $\chi$, equal to 0.005 in the pre-1980 period; in the post-1980 period, we assume that it has dropped to 0.0025 to account for the relaxation of capital controls.

We set the parameters pertaining to capital accumulation at values that are standard in the business cycle literature. We set $\delta$, the quarterly depreciation rate, to make capital depreciate at a 10% annual rate. Following Christiano, Eichenbaum, and Evans (2005), we set $\phi_i$, the investment adjustment cost parameter to 2.5.

We characterize monetary and fiscal policy by estimated rules. We use Lubik and Schorfheide’s (2007) estimate of the Canadian Taylor rule. For Canadian government spending we assume that the (log of) spending follows an AR(1) process. We applied a linear trend on the relevant series from the national accounts and then fit an AR(1) process for each of the two sample periods. The persistence coefficients are 0.96 and 0.78 and the standard deviation of the innovations 2.09% and 1.54%, respectively.16

We assume all shocks follow AR(1) processes. We also assume that the rest of the world can be approximated by the U.S. The processes for world output and world inflation were estimated using U.S. data. The (log of) output was linearly detrended; then, the technology shock was estimated using Solow residuals. We built a capital series by iterating on investment (obtained from the national accounts). Then, using the employment and output data, we calculated a Solow residual and estimated the AR(1) process for technology. The preference shock was calibrated using U.S. demand for the Canadian good. As a consequence, $x^\star_d$ is identified as Canadian exports to the U.S. And, the U.S.-Canadian terms of trade appears in the world demand function for Canadian goods. Using the value for $\rho$ and $\omega^\star$, we built a series for the preference shock and estimated an AR(1) process for it.

2. THE EVOLUTION OF GOVERNMENT SPENDING MULTIPLIERS

Now, we are ready to see how our model would explain the evolution of government spending multipliers that has been observed in the data. It is instructive to begin with

\[ \log(G_t) = \alpha_1 + \beta_1 t + \rho_1 \log(G_{t-1}) + \alpha_2 I_{1980Q1} + \beta_2 I_{1980Q1} \times t + \rho_2 I_{1980Q1} \times \log(G_{t-1}) + u_t. \]

The Fisher test for the joint significance of the interaction terms ($H_0: \alpha_2 = \beta_2 = \rho_2 = 0$) has a value $F = 2.39$ and is distributed as a Fisher (3,161), which leads us to reject the null with a probability value of 0.07.

16. We have checked for the statistical significance of this difference by regressing the log of government expenditures on its lagged values, a constant, a trend, and the interaction between each of these variables and a dummy variable that equals 0 in the pre-1980 and 1 in the post-1980 period:

\[ \log(G_t) = \alpha_1 + \beta_1 t + \rho_1 \log(G_{t-1}) + \alpha_2 I_{1980Q4} + \beta_2 I_{1980Q4} \times t + \rho_2 I_{1980Q4} \times \log(G_{t-1}) + u_t. \]
the special case of perfect information, then we will proceed to the more interesting case of imperfect information.

2.1 The Case of Perfect Information

Here we assume that households and firms observe macroeconomic variables without error, and that there is therefore no signal extraction problem. Table 5 shows the cumulative output multipliers for an increase in government spending at horizons of one, four, and eight quarters. The multipliers fall short of unity and are roughly the same size across the two benchmark calibrations of the model. This finding is inconsistent with both the documented decline in the Canadian spending multiplier over time and the Ilzetzki, Mendoza, and Vegh (2010) results that indicate substantial differences across exchange rate systems and moreover multipliers that are about zero under flexible rates.

Figure 2 sheds light on these results. The impulse response functions for consumption and investment show a decline under either calibration, while hours worked rise. This is a familiar result from the real business cycle (RBC) literature. Households see that the increase in government spending translates into higher taxes. They respond by working more, consuming less, and investing less. The increase in taxes follows the same process as G. As the G-shock follows an AR(1) process, the direct, negative effects of government spending on consumption are tilted toward the present. Consumption smoothing then implies that the supply of savings declines, which reduces foreign assets and pushes interest rates up (recall that international asset markets are imperfect). At the same time, a higher level of employment increases the profitability of capital and thus the demand for investment. The net effect on the quantity of investment depends on the relative shift of the supply of savings—demand for investment and hence on the real interest rate. While the effect is negative in our benchmark parameterization, it could be positive if, for instance, the G-shock were more persistent (hence smaller negative shift in the savings curve), investment adjustment costs were lower (larger positive shift in the investment curve), the labor demand curve flat, and so on.

The reason that the multiplier is—slightly—higher under a fixed regime has to do with the persistence of the government spending shock. It is more persistent in the period with the fixed exchange rate regime so the associated wealth effect is stronger. On the one hand, this means a larger drop in aggregate demand (consumption and investment) but on the other hand, a larger increase in the supply of labor. Under the benchmark calibration, the supply effect dominates the demand effect, leading to larger output effects under a fixed regime.
Due to the decrease in consumption and investment, the output multipliers are less than unity under either regime. Something must be done in order to counter the negative wealth effect on aggregate demand if the model is to explain the empirical observations.

As explained earlier, we have chosen to do this by adding imperfect information. From now on, we assume that households and firms have to base their decisions on imperfect signals about the macroeconomic shocks.

2.2 Imperfect Information: Output Multipliers in the Benchmark Calibrations

The first and last lines of Table 6 report the cumulative output multipliers for our two benchmark calibrations. In the $B_{\text{Fixed}}$ calibration, the first-quarter multiplier is greater than one and then the multipliers tapers off at the four- and eight-quarter horizons. In the $B_{\text{Flex}}$ calibration, the multipliers are dramatically smaller at all horizons. These model-generated multipliers capture remarkably well the reduction in spending multipliers that accompanied the change in monetary policy practices.
TABLE 6
EXPERIMENTS (INDIVIDUAL EFFECTS)

<table>
<thead>
<tr>
<th>Model</th>
<th>$\mu_1$</th>
<th>$\mu_4$</th>
<th>$\mu_8$</th>
</tr>
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<tr>
<td>(1) Benchmark fixed</td>
<td>1.5309</td>
<td>1.0536</td>
<td>0.6393</td>
</tr>
<tr>
<td>(2) Flexible exchange rate</td>
<td>-0.1993</td>
<td>0.2266</td>
<td>0.5076</td>
</tr>
<tr>
<td>(3) Lower capital control ($\lambda = 0.0025$)</td>
<td>1.3328</td>
<td>0.8982</td>
<td>0.5651</td>
</tr>
<tr>
<td>(4) Higher imports ($\omega = 0.72$)</td>
<td>0.8648</td>
<td>0.5309</td>
<td>0.3552</td>
</tr>
<tr>
<td>(5) New volatility ($\sigma_\tau = 0.0154$)</td>
<td>1.5986</td>
<td>1.1268</td>
<td>0.6862</td>
</tr>
<tr>
<td>(6) New persistence ($\rho_\tau = 0.78$)</td>
<td>1.6442</td>
<td>1.1467</td>
<td>0.6151</td>
</tr>
<tr>
<td>(7) New fiscal shock ($\rho_\tau = 0.78, \sigma_\tau = 0.0154$)</td>
<td>1.6794</td>
<td>1.1886</td>
<td>0.6443</td>
</tr>
<tr>
<td>(8) Benchmark flexible</td>
<td>0.1364</td>
<td>0.2393</td>
<td>0.4270</td>
</tr>
</tbody>
</table>

Figures 3 and 4 show impulse response functions (IRFs) from the two benchmark calibrations. With imperfect information, consumption and investment respond positively to an unanticipated increase in government spending. And this increase in aggregate demand is much more pronounced in the $B_{\text{fixed}}$ calibration, explaining the much larger response of GDP in the case of fixed rates.

Why do consumption and investment rise when we add imperfect information? The answer lies in Figure 5, which shows how households’ perceptions of the paths of the underlying shocks are affected by an unanticipated increase in government spending. Households do not know exactly what kind of shocks have occurred. The perceptions they form about what they observe (recall that they observe the nominal interest rate and the exchange rate without error while they observe the other variables with noise) are such that they assign probabilities to an increase in government spending, to an improvement in technology, to an increase in world inflation, and to an increase in foreign preference for the domestic good having taken place. The first possibility would lower permanent income (by increasing tax liabilities), but all of the other possibilities would increase their permanent income. In equilibrium, confusion about the source of the shock causes the perceived wealth effect to be positive, and households increase their consumption and investment.$^{17}$

In order to shed some light on these results it is instructive to solve the model under a flexible exchange rate regime and passive monetary policy (e.g., a constant money growth rule). Under perfect information, following a positive fiscal shock there is a modest increase in inflation (0.028) and a small depreciation of the currency (0.023). The multiplier is less than unity (0.89). Under either a peg or a flexible exchange rate regime with a Taylor rule the monetary policy reaction involves a small tightening. The multiplier declines in both regimes.

The picture is completely different under imperfect information. In this case, the multiplier is negative under the M-rule, there is a reduction in inflation—relative to the

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$^{17}$ As noted earlier, adding rule of thumb consumers is the more popular way of making the consumption response positive. However, that approach has problems with the response of real wages, which Fatas and Mihov (2003) find to be positive in the data. Our model predicts a positive response of real wages.
steady state—\((-0.15)\) and also a large appreciation of the domestic currency \((-0.4)\). The underlying mechanism is as follows (see Figure 6): because of misperceptions, the increase in government spending leads to higher domestic demand for consumption and investment. As domestic output is not affected much, home bias in spending
creates an excess demand for domestic relative to foreign goods. The relative price of the domestic goods must increase (the terms of trade, \( eP^*/P \), must improve for the home country). The required relative price change can be accomplished by a combination of changes in the exchange rate and the nominal price of the domestic good, which then cause changes in the general price level (inflation), the target of policy under a Taylor rule. Consequently, the sign and relative size of the changes in the exchange rate/inflation rate will determine the size of the monetary policy reaction and hence the contribution of the exchange rate regime to the multiplier. For instance, if the appreciation were large while the change in the inflation rate (this depends on the specification of the demand for money demand) the reaction of policy would be stronger under a fixed regime than under a Taylor-run flexible regime, making the multiplier larger under the former. This is the case in our benchmark specification.

The monetary reaction to price developments is rather weak (recall that \( \kappa_\pi = 1.3 \)) so the monetary expansion is modest, which limits the size of the increase in the
multiplier relative to both the M-rule and the peg. If the monetary authorities were strict inflation targeters\footnote{Strict inflation target, say, $\kappa_\pi = \infty$, $\kappa_y = 0$, would make the multiplier increase by an order of four! Nevertheless, the multiplier would still remain smaller than unity. And it would remain smaller under a flexible regime because the size of the decrease in inflation is small relative to that in the exchange rate.} (see Section 2.5), then the multiplier would be bigger.

2.3 A Change in Fiscal Policy, a Change in Monetary Policy, or Globalization?

What are the factors that account for the rather dramatic fall in government spending multipliers? There are three candidates in our modeling. The first is the change in the stochastic properties of government spending, namely, that it became less persistent/volatile.\footnote{Lower volatility of G implies more frequent misperceptions—a larger share of G-shocks is now attributed to other shocks—and thus larger multipliers. We are grateful to a referee for pointing this out.} The second is monetary policy: in the Bflex calibration, the fixed rate regime yields to an estimated interest rate rule that places very little weight on exchange rate stabilization. And the third is globalization: in the Bflex calibration,
capital controls (modeled as a cost of holding foreign assets) are relaxed, and the economy is more open to trade.

In Table 6, we consider these factors one at a time. In the second line, we have replaced the fixed exchange rate regime with the estimated Taylor rule, but we have held all of the other parameters in the Bfixed calibration unchanged. In the third line, we have relaxed the capital controls, but we held all the other parameters unchanged. In the fourth we consider a change in openness. Lines 5 through 7 take a closer look at the effects of the change in the stochastic process for government spending, both the persistence and volatility of innovations.

The change in monetary policy clearly makes the largest marginal contribution to the fall in government spending multipliers; for example, it brings the first quarter multiplier 113% of the way to the multiplier in the Bflex calibration. Openness is the next most important factor, in terms of its marginal contribution (44% of the way for the first-quarter multiplier). Relaxing capital controls is a rather distant third (about 13%). And changes in the process of fiscal policy actually increase the multipliers slightly: when the government spending process becomes more stable, households put more weight on the possibility of other shocks, and they increase their consumption more (line 6).
There is, however, a caveat here: the marginal contributions in Table 6 do not necessarily capture the independent contribution of each individual factor because these factors interact with each other when they are combined, as in the Bflex calibration. In other words, the marginal contributions are not orthogonal to each other, and the cumulative effects of adding one factor after another depend upon the order in which they were added. There is no way around this problem, one can only try out alternative orderings to see whether they make a big difference.

Table 7 relies on such an alternative ordering. It reports the cumulative marginal contributions that the factors make when they are added in a specific way. First, based on Table 6, we selected the factor with the largest individual marginal contribution; this is the change in monetary policy. We imposed this change, and then we considered each of the other factors, one at a time. We selected the factor that, once again, made the largest marginal contribution. This led us to select openness. We continued the process, selecting looser capital controls, and then the more stable fiscal process.

Looking at either Table 6 or Table 7, the change in monetary policy is clearly the most important factor in the model’s explanation of the evolution of government spending multipliers. One of the globalization factors—openness—also seems to be important. Both of these findings are in line with the findings of Ilzetzki, Mendoza, and Vegh (2010). Finally, easing capital controls is somewhat important, and luck seems quite unimportant.

2.4 How Flexible Rates and Openness Reduce the Government Spending Multipliers

The IRFs in Figures 7 and 8 help explain the progression of multipliers in Table 7. In Figure 7, IRFs from the Bfixed calibration are compared to IRFs from a calibration in which the fixed exchange regime has been replaced by the estimated Taylor rule, and all other parameters are as in the Bfixed calibration; this corresponds to moving from line 1 to line 2 in Table 7. In Figure 8, the second set of IRFs from Figure 7 are compared to IRFs from a calibration in which we have both the Taylor rule and increased openness; this corresponds to moving from line 2 to line 3 in Table 7.
In Figure 7, the importance of flexible rates is readily apparent: the response of GDP to an unanticipated increase in government spending is much greater in the fixed rate regime. The reason for this is also readily apparent. With flexible rates, the nominal exchange rate would appreciate. Monetary policy must be loosened to counter this in the fixed rate regime. Real interest rates fall further than they would with the Taylor rule, and this causes both consumption and investment demand to
rise more. And, of course, the fact that the exchange rate does not appreciate means that more of the increase in consumption falls on the domestic good.20

20. The terms of trade must appreciate with the Taylor rule for this “Mundell–Flemming” explanation to work. There is currently some debate about this in the empirical literature. Ravn, Schmitt-Grohe, and Uribe (2012) and Monacelli and Perotti (2006) find that the real exchange rate depreciates. Canzoneri,
In Figure 8, the importance of openness is also apparent: the response of GDP is less when the import share is larger. When a larger import share of the increase in demand falls more on the foreign good, and aggregate demand for the domestic good rises less. With the Taylor rule, the appreciation in terms of trade is smaller and the fall in net exports is dampened.

2.5 Money Targeting and Strict Inflation Targeting

Since the change in monetary policy was shown to be the most important factor in the evolution of the model’s multipliers, it may also be interesting to consider alternative specifications of monetary policy. Table 7 shows how the multipliers in the Bfex calibration would change if the estimated Taylor rule were replaced by a fixed money growth rule or a stricter inflation targeting rule (where $\kappa_\pi = 3$ and $\kappa_y = 0$ in row (7) and $\kappa_\pi = \infty$ and $\kappa_y = 0$ in row (8)).

The money growth rule is interesting for conceptual reasons: it is the logical counterpart to the fixed exchange rate regime in the “Mundell–Flemming” paradigm. The output multipliers are lower under the money growth rule than under the estimated Taylor rule or under the fixed exchange rate. This is due to the fact that the model generates a reduction in inflation and an appreciation in the nominal exchange rate under the money targeting rule. Under the Taylor rule, the monetary authorities react to the lower inflation by lowering interest rates, which stimulates the economy. Similarly loose policy must be followed under a peg in order to prevent the appreciation of the domestic currency.

The strict inflation targeting rule is interesting because of two reasons. First, it may be where central banks in the OECD countries are heading. As explained earlier, stricter inflation targeting gives a stronger response to the government spending shocks than does a standard Taylor rule. The stronger reaction of monetary policy to the reduction in inflation that would have occurred under passive money growth policy is behind this result. And second, because the fact that the spending multipliers went down also in countries such as the U.S. where there was no change in the exchange rate regime means that there must be other factors besides the international monetary arrangement that may have contributed to the decline of the multipliers. A change in monetary policy away from money targeting toward interest targeting and the adoption of a more aggressive low inflation stance have been offered as alternative explanations. Our analysis indicates that, if anything, such changes would have made the multipliers larger, not smaller.

3. CONCLUSION

We have shown that a New Keynesian model is capable of explaining the evolution of consumption responses and output multipliers that has been observed in the data.
when the model is augmented to include imperfect information about the shocks. Imperfect information’s key contribution is to help the model overcome the negative wealth effect that normally decreases consumption in response to an increase in government spending. In our model, the response of consumption is positive. We find that monetary policy’s movement away from exchange rate stabilization, and to a standard Taylor rule, is the most important factor in accounting for observed differences in spending multipliers. However, globalization (in the form of increased openness, and to a lesser extent, the relaxation of capital controls) also plays a role. A more stable government spending process does not seem to have been an important factor.

APPENDIX

FORECASTING REGRESSIONS: ROBUSTNESS

**TABLE A1**

<table>
<thead>
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<th>Forecasting Regressions</th>
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<td>(0.237)</td>
<td>(0.016)</td>
<td>(0.202)</td>
<td>(0.471)</td>
<td>[0.377]</td>
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<td>0.056</td>
<td>0.026</td>
<td>0.014</td>
<td>−</td>
<td>0.92</td>
<td>2.34</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>(0.003)</td>
<td>(0.149)</td>
<td>(0.016)</td>
<td>(0.199)</td>
<td>−</td>
<td>[0.435]</td>
<td></td>
<td></td>
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<tr>
<td>0.002</td>
<td>−</td>
<td>−</td>
<td>0.011</td>
<td>−</td>
<td>0.00</td>
<td>2.32</td>
<td>0.00</td>
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<tr>
<td>(0.002)</td>
<td></td>
<td>(0.196)</td>
<td></td>
<td>−</td>
<td>[0.955]</td>
<td></td>
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<tr>
<td>−0.000</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>0.264</td>
<td>0.85</td>
<td>2.31</td>
<td>0.01</td>
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<tr>
<td>(0.002)</td>
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<td>(0.285)</td>
<td></td>
<td>−</td>
<td>[0.360]</td>
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</tr>
</tbody>
</table>

Note: $R = \text{federal fund rate}$, $\Delta S&P = \text{changes in the S&P stock market index}$, $\Delta Y = \text{changes in GDP}$, $\pi = \text{inflation rate (GDP deflator)}$. Standard deviations in parentheses.

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