Indivisible Labor in a Small Open Economy Model†

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Abstract

In this paper traditional use of Greenwood, Hercowitz, and Huffman (GHH, 1988) preferences in the SOE literature are abandoned in favor of general preferences in utility following King, Plosser and Rebelo (1988). These preferences have been previously argued to be unsuccessful in obtaining SOE business cycle movements in the trade balance and consumption consistent with the data. This paper revisits the use of general preferences in a SOE model and finds that when combined with indivisible labor, the model is successful in replicating the Canadian economy with respect to the trade balance, consumption and as well as total labor hours. With indivisible labor consumption volatility rises causing a countercyclical trade balance as found in the Canadian data. In addition, indivisible labor allows for the movement in total hours to be due to the extensive margin, which is showed to be relatively more important in Canada than the intensive margin considered in the literature.

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1. INTRODUCTION

This paper departs from standard small open economy (SOE) real business cycle models as in Mendoza (1991), Schmitt-Grohe and Uribe (2003), Letendre (2004), etc., by modeling involuntary unemployment. Following Hansen (1985) and Rogerson (1988) indivisible labor is introduced in a SOE model calibrated for Canada, wherein agents are assumed to either work a fixed number of hours or not at all. Moreover, traditional use of preferences postulated in Greenwood, Hercowitz, and Huffman (GHH, 1988) – that place restrictions on labor market behavior – are abandoned in favor of general preferences in utility following King, Plosser and Rebelo (1988) that have been previously argued to be unsuccessful in generating SOE business cycle moments consistent with the data. Specifically, Correia, Neven and Rebelo (1995) and Schmitt-Grohe and Uribe (2003) find general preferences to yield much too low standard deviation of consumption and a counterfactual procyclical trade balance. Motivated by their findings, this paper incorporates indivisible labor into a SOE model with general preferences via King, Plosser and Rebelo (1988). The model is able to overcome the irregularities reported by Correia, Neven and Rebelo (1995) and Schmitt-Grohe and Uribe (2003). In addition, the general preference-indivisible-labor model better matches the dynamics of total hours to the data than the standard SOE model. Consequently, this paper demonstrates that general preference are able to yield business cycle moments consistent with the data; and for the first time incorporates involuntary unemployment into a small open economy model.

In their 1992 paper, Bacus, Kehoe and Kydland find that the relationship between trade balance and output is positive when looking at quarterly data for 12 developed
countries. In order to obtain this stylized fact in a small open economy dynamic general equilibrium model, agent’s preferences are represented via the GHH utility function. General preferences in contrast yield a counterfactual high positive correlation and a low volatility in consumption, and in general have been deemed unsuitable in replicating a small open economy such as Canada or Spain. Although, GHH preferences yield tractable business cycle properties with respect to trade balance, consumption and output, it leads to anomalies with respect to labor hours. Mendoza (1991) recognizes these anomalies, as do Greenwood, Hercowitz, and Huffman (1988). First, GHH preferences imply an automatic unitary correlation between total hours and output due to the lack of a wealth effect. With general preferences, this restriction is removed and the correlation falls below one. Second, the volatility of total hours in standard SOE models is too low, and is not statistically significant at the 5% or 1% level. With general preferences and indivisible labor, standard deviation rises and is significant at the 1% level.

The typical modeling strategy of SOE models has been to follow Kydland and Prescott (1982) and have labor be divisible. This paper takes an alternative approach following Hansen (1985), Rogerson (1988), Rogerson and Wright (1988) by having agent either supply a fixed number of hours, or supply zero. Given the non-convexity in preferences, lotteries are utilized to convexify the choice set. Individual agents enter a

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1 Similar results obtain in Backus and Kehoe (1992), who look at a hundred years of annual data for 10 developed countries, and in the empirical work of Krugman and Baldwin (1987).


3 In Hercowitz, and Huffman (1988) GHH preferences allow the authors to stress the variable capital utilization propagation mechanism of investment shocks. Moreover, eliminating the intertemporal substitution effect on labor effort eliminates the potential problem that this mechanism can generate in the presence of investment shocks, i.e. a fall in consumption as individuals postpone leisure. This was an important point for their findings.

4 An alternative approach to reduce the correlation between output and hours is take up in Guo and Janko (2007), where intertemporal labor supply and variable capital utilization are combined in the standard SOE model of Mendoza (1991). This approach yields a correlation close to the data.
lottery that with some positive probability determines whether they work or remain unemployed. Hence, individuals enter into a contract that allows for random layoffs and the lottery itself determines whether one is employed or is unemployed. As long as agents do not face log-log utility with indivisible labor the consumption of employed workers is higher than the consumption of unemployed. This leads to an increase in the volatility of consumption, closely matching the Canadian data, and the standard deviation is significant at the 5% level. As in the standard SOE model, agents use the trade balance to smooth out consumption, however with higher volatility of consumption the response of the trade balance becomes countercyclical. The indivisible labor model yields a correlation of -0.343 as compared to 0.986 when labor is divisible.

Lastly, the value of the risk aversion parameter turns out to be important in matching the Canadian economy. With the relative risk aversion parameter equal to 1, the utility function is log-log. In this case, both employed and unemployed consume the same level of consumption, and the total volatility of consumption rises only slightly as does labor and output. Moreover, trade balance remains procyclical as in the divisible labor case. A rise in the relative risk aversion coefficient yields improvements in the volatility of consumption, labor and output, and obtains a negative correlation between output and the trade balance.

The paper is organized as follows. Section 2 gives a motivation for incorporating indivisible labor in modeling total hours for Canada. The model is presented in section 3. In section 4 the equilibrium, the solution method and the calibration are discussed. Section 5 presents the simulation findings for both divisible and indivisible labor.

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5 The use of log-log utility (relative risk aversion of one) as in Hansen (1985) implies identical consumption between employed and unemployed workers and only slightly changes the volatility of aggregate consumption.
sensitivity analysis to the relative risk aversion parameter is conducted in section 6. Section 7 concludes the paper.

2. DATA

This section discusses the business cycle properties of total hours, employment, hours per worker, and output, in order to motivate the adoption of indivisible labor. All series are quarterly Canadian data from 1981.1 to 2001.4, and are logged and de-trended using the Hodrick-Prescott filter. Figure 1 plots the cyclical component of employment and hours per worker relative to total hours (in panel a and b respectively). The findings indicate that employment fluctuations are relatively more important in explaining the business cycle properties of total hours as compared to hours per worker. Specifically, the volatility of total hours is 1.6 with the standard deviation of employment and hours per worker being 1.21 and 0.7 respectively. In addition, the correlation between total hours and employment (=0.9313) is higher than the correlation between total hours and hours per worker (=0.8007). Hence, modeling the extensive margin is relatively more important in understanding the business cycle properties of total hours.6

In addition, figure 2 shows that fluctuations in employment are also relatively more important in explaining output fluctuations than are fluctuation in hours per worker. The correlation between output and employment is 0.91 while that of output and hours per worker is much lower, near 0.65. Thus, the data supports the departure undertaken in this paper in modeling the extensive margin (indivisible labor).

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6 These findings are consistent with the findings reported in King and Rebelo (1999) for US aggregate data.
3. THE ECONOMY

The economy consists of a unit measure of identical, infinitely-lived individuals who maximize expected discounted lifetime utility

$$E \sum_{t=0}^{\infty} \beta^t U(c_t, l_t),$$

where $\beta \in (0, 1)$, $c_t$ is consumption, and $l_t$ is leisure.

In contrast to the standard SOE literature that relies on GHH preferences:

$$U(c_t, l_t) = \left\{ \left[ \left( 1 - \frac{(1-l_t)^{\omega}}{\omega} \right)^{\frac{1}{1-\sigma}} \right] - 1 \right\}, \quad \omega > 1, \sigma > 0,$$

the functional form of the momentary utility function exploited here follows King, Plosser and Rebelo (1998) and is the one considered by Schmitt-Grohe and Uribe (2003) and Correia, Neven and Rebelo (1995). It is given by

$$U(c_t, l_t) = \left\{ \left[ \left( \frac{c_t}{l_t} \right)^{\frac{\omega}{1-\omega}} \right]^{1-\sigma} - 1 \right\}, \quad 0 < \omega < 1, \sigma > 0,$$

$\sigma$ is the relative risk aversion parameter. The utility function is nonseparable in consumption and leisure, concave and twice continuously differentiable. Agents in the economy are endowed with one unit of time that they allocate between leisure and labor.

In addition, individuals are assumed to either work $h_0 > 0$ fixed hours or not at all, which introduces non-convexities in preferences. Following Rogerson (1988), Hansen (1985) and Hansen and Sargent (1988) employment lotteries are utilized to convexify the choice
set. At the beginning of period \( t \) individuals enter a lottery that, with probability \( p \) determines whether they work and with probability \( 1-p \) remain unemployed. Hence, individuals enter into a contract that allows for random layoffs and the lottery itself determines whether one is employed (and receives an income that allows him to consume \( c_{1t} \)) or is unemployed (receiving an income that allows for the consumption of \( c_{2t} \)). Thus prior to the draw of the lottery the expected utility for an individual is

\[
p u(c_{1t}, 1-h_0) + (1-p)u(c_{2t}, 1). \tag{4}
\]

Total consumption allocation across both types of individuals must satisfy the pfeasibility condition

\[
p c_{1t} + (1-p)c_{2t} = c_t. \tag{5}
\]

Maximizing (4) subject to the constraint in (5) yields the risk-sharing condition

\[
\frac{c_{1t}}{c_{2t}} = \left(\frac{1}{1-h_0}\right)^{(1-\omega)(1-\sigma)\sigma^{-1}}, \tag{6}
\]

that states that employed agents consume more than unemployed agents as long as \( \sigma > 1 \). With log-log preferences as in Hansen (1985), the risk sharing condition together with the pfeasibility condition implies \( c_{1t} = c_{2t} = c_t \), thus all agents consume the same level of consumption. This latter specification is known to only slightly increase aggregate consumption and is ignored in this paper. The assumption of nonseparable preferences in consumption and leisure implies that shocks to technology that alter total hours lead to variations in consumption. Specifically, in the \( \sigma > 1 \) case consumption and labor move

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7 Convexifying the set via lotteries allows agents to be better off ex ante and thus is welfare improving. Rogerson and Wright (1988) provide a thorough welfare analysis in economies with involuntary unemployment via indivisibilities in labor.

8 Henceforth, subscript 1 is used for employed workers and subscript 2 for unemployed workers.

9 See Greenwood and Huffman (1988) and Rogerson and Wright (1988) for a complete discussion.
proportionately, hence consumption can be much more volatile in the indivisible labor model as compared to a model with standard preferences and divisible labor considered in Correia, Neves, and Rebelo (1995) and Schmitt-Grohe and Uribe (2003).

Using Eq. (6) and (5) in (4) yields, after some algebra, the utility function of a ‘representative’ consumer:

\[
U(c_t, l_t) = \frac{e^{\gamma_t \Phi(l_t)^{\gamma_t} - 1}}{1 - \sigma},
\]

where

\[
\Phi(l_t) = \left[ p(1-h_0)^{\gamma_1} + (1-p)(1-h_0)^{\gamma_2} \right],
\]

where \( l_t = 1 - ph_0 \), \( \gamma_1 = -\left(\omega(1-\sigma)-1\right) \) and \( \gamma_2 = (1-\omega)(1-\sigma) \). Total hours in the economy \( h_t \) are given by \( ph_0 \) and change due to changes in \( p \), the employment rate. Note that ex-post the lottery, the economy can be seen as being occupied by a representative agent that chooses \( h_t \).

The budget constraint of the representative consumer is given by

\[
c_t + i_t + (1 + r_{t-1})d_{t-1} + \psi(d_t - \overline{d})^2 = y_t + d_t, \quad \psi > 0,
\]

where \( i_t \) is investment and \( r_{t-1} \) is the international real interest rate on foreign debt \( d_t \). Agents are assumed to incur positive portfolio adjustment costs whenever foreign debt differs from its long run level \( \overline{d} \). This assumption is made for purely technical reasons, as without portfolio adjustment costs the equilibrium is nonstationary.\(^{10}\)

Lastly, output is produced using a constant returns to scale Cobb-Douglas production function:

\[^{10}\text{Schmitt-Grohe and Uribe (2003) consider alternative approaches to introducing stationarity, such as the endogeneous discount factor utilized by Mendoza (1991) and Guo and Janko (2007). They find the simulated moments to be highly insensitive to different stationarity inducing mechanisms.}\]
\[
y_t = e^{x^t} k_t^{\alpha} h_t^{1-\alpha}, \quad 0 < \alpha < 1, \tag{9}
\]

where \( k_t \) is capital and \( z_t \) represents the technology shock. The production function is increasing in both its arguments and is twice continuously differentiable. The technology shock is assumed to evolve according to

\[
z_t = \rho z_{t-1} + \varepsilon_t, \tag{10}
\]

where the random variable \( \varepsilon_t \) is i.i.d. with mean zero and a standard deviation of \( \sigma_z \).

Capital stock in the economy evolves according to the following law of motion

\[
k_{t+1} = (1-\delta)k_t + i_t - \phi(k_{t+1} - k_t)^2, \quad \phi > 0, \tag{11}
\]

where \( \delta \in (0,1) \) represents the capital depreciation rate. The last term in (11) gives the capital adjustment costs of net investment.\(^{11}\)

The first-order conditions of the representative household with respect to \( h_t, c_t, k_{t+1}, \) and \( d_t \), and the associated transversality conditions (TVC) are

\[
\begin{align*}
\lambda_t & : \lambda_t \frac{\partial y_t}{\partial h_t} = \left( \frac{\gamma_1}{1-\sigma} \right) c_t^{\gamma} \Phi(1-h_t)^{\gamma-1} \frac{\partial \Phi(1-h_t)}{\partial h_t} \tag{12} \\
c_t & : \lambda_t = \left( \frac{1-\gamma_2}{1-\sigma} \right) c_t^{\gamma} \Phi(1-h_t)^{\gamma} \tag{13} \\
k_{t+1} & : \lambda_t \left[ 1 + 2\phi(k_{t+1} - k_t) \right] = \beta E \left\{ \lambda_{t+1} \left[ 0 e^{x^t} k_t^{\alpha} h_t^{1-\alpha} + 1 - \delta + 2\phi(k_{t+1} - k_{t+2}) \right] \right\}, \tag{14} \\
d_t & : \lambda_t \left[ 1 - 2\psi(d_t - \overline{d}) \right] = \beta (1+r_t) E \lambda_{t+1}, \tag{15} \\
\text{TVC}_t & : \lim_{j \to \infty} \frac{d_{t+j}}{\Pi_{i=0}^{j-1} (1+r_{t+i})} \leq 0, \tag{16}
\end{align*}
\]

\(^{11}\) Mendoza (1991) finds that without capital adjustment costs the volatility of investment is much too high, due to the household’s ability to borrow from abroad to finance domestic investment in the presence of a positive technology shock.
TVC_1 : \lim_{j \to \infty} E \left[ 0_{t+j} \lambda_{t+j} k_{t+j} \right] \leq 0, \quad (17)

where \( \lambda_i \) is the marginal utility of consumption given in (13). Equation (12) is the intra-temporal condition that equates the real value of the marginal product of labor to the representative consumer’s marginal rate of substitution between consumption and leisure and equation (14) gives the Euler equation for intertemporal consumption choices.\(^{12}\) The representative consumer’s intertemporal choices of foreign bonds are governed by (15).

3. EQUILIBRIUM, SOLUTION METHOD AND CALIBRATION

The competitive equilibrium is a set of stochastic processes \( \{c_t, h_t, k_{t+1}, y_t, d_t, \lambda_{t_j}\} \) that satisfy equations (8)-(9), the law of motion for capital (11), the first-order conditions (12) - (15) together with the productivity disturbance (10), the initial conditions \( z_0, k_0, \) and \( d_{-1}, \) and the transversality conditions in (16)-(17). Finally, the world’s interest rate is assumed to be constant and equal to \( r \).

The model is solved using the method of undetermined coefficient (Campbell, 1994). The results of this procedure are recursive equilibrium laws of motion for the variables of interest. A general representation postulating a linear relationship between the decision variables and the state variables is given by

\[
X_t = AX_{t-1} + Bw_t \\
V_t = CX_{t-1} + Dw_t, \quad (18)
\]

where \( X_t \) is an endogenous state vector, \( V_t \) is a vector of other endogenous variables and \( w_t \) is a vector of stochastic processes. The stochastic process considered here is the

\(^{12}\) With the commonly used GHH preferences in the SOE literature the condition in Eq. (12) does not depend on consumption, hence no income effect. In contrast, in Eq. (12) the income effect plays a role.
technology shock. The objective is to solve for the matrices $A$, $B$, $C$, and $D$ in order to obtain equilibrium decision rules for $X_t$ as well as equilibrium decision rules for $V_t$.

Since the equations in (18) are postulated recursive laws of motion, the coefficients in matrices $A$, $B$, $C$, and $D$ are undetermined. In order to solve for all matrices the equations characterizing the equilibrium are log-linearized around the steady state; that includes the first-order-conditions of the representative household, the budget constraint, the output function, and the law of motion for capital.\footnote{The equations characterizing the equilibrium in log deviation form are given in the Appendix.} Together, the postulated laws of motion and the log-linearized equilibrium equations from the model are used to solve for the undetermined coefficients using an algorithm formulated by Uhlig (1999).

The values of the parameters are obtained from prior studies. Following Mendoza (1991), the discount factor $\beta$ is set at 0.993, the capital’s share in total income $\alpha$ is set at 0.32, and the coefficient of relative risk aversion is set at 2.\footnote{The empirical findings with respect to the relative risk aversion parameter are mixed. Szpiro (1986) estimates fall between 0.5-0.8, Fullenkamp et. al (2003) find the value to be between 0.5-1.5 and Cichetti and Dublin (1994) estimate is close to 1.67. Moreover, recent studies have argued that relative risk aversion changes with age, education, stake size, etc. See for example Bellante and Green (2004) and Fehr-Duda, et al. (2007).} All of these values are calibrated to Canada. The depreciation rate $\delta$ is set equal to 0.02 corresponding to an 8% annual depreciating rate. Lastly, the value of $\omega$ is set to 0.22 as in Schmitt-Grohe and Uribe (2003) so that the steady state total hours equal 0.2 when labor is divisible. In the indivisible labor model, $h_0$ and $p$ are chosen so that the steady state level of total hours $h$ is again equal to 0.2, and $\omega$ is left at 0.22.

In the divisible labor economy the portfolio adjustment costs parameter $\psi$ is set to match the volatility of the trade balance to output ratio and the capital adjustment costs parameter $\phi$ is set to ensure that the volatility of investment to the volatility of output
ratio in the model matches the one in the data. Indivisible labor lowers the relative volatility of investment to output for all values of $\phi$, and thus we use the same value of $\phi$ as in the divisible labor case while $\psi$ is again set to match the standard deviation of the trade balance to output ratio. Finally, the values of $\rho$ and $\sigma_z$ are obtained from Letendre (2004) and are set equal to 0.944 and 0.006 respectively.

4. QUANTITATIVE RESULTS

The resulting statistics reported in Tables 1 and 2 are sample means computed over 1000 simulations, where all series are passed through the Hodrick-Prescott filter. The model is simulated for 84 periods, the same number as in the Canadian sample, 1981.1-2001.4. Statistics that display the superscript * and ** indicate that a moment is significant at the 5% and 1% level, respectively.

4.1 Divisible vs. Indivisible labor

Table 1 gives the sample statistics typically reported in the SOE literature. The first column gives the moments for Canadian data, followed by results for the devisable labor economy (both Correia, et al (1995) and Smitt-Grohe and Uribe (2003) consider this type of model), and the last column gives the findings for the involuntary unemployment economy. The results in column two confirm the findings of Correia, et al (1995) and Schmitt-Grohe and Uribe (2003). With divisible labor the volatility of consumption is too low as consumption is excessively smoothed over time. Moreover, a positive technology shock increases output and the trade balance leading to a high positive correlation between consumption and leisure. For these two reasons the general preferences of King, Plosser and Rebelo (1988) have been deemed unsuitable in the SOE literature, generally abandoned in favor of the GHH preferences.
Introducing involuntary unemployment into the SOE model with general non-GHH preferences allows the model to come close to matching the Canadian economy along dimensions that the divisible economy is unable to do. With indivisible labor (as shown in Eq. (6)) the consumption of employed is much higher than that of unemployed. Thus, when individuals in the economy are hit by a technology disturbance, output of employed rises as does the level of employed workers, and thus employed consume more relative to unemployed (45% more given the value of $\sigma$), raising aggregate consumption. Hence, unlike in the divisible labor model, here consumption rises more due to the income differences across the two types of individuals. Overall, this has the desired affect of increasing the volatility of consumption and consequently better matching the Canadian data. Furthermore, with involuntary unemployment the relative volatility of consumption to that of output is almost entirely matched, with the standard deviation of consumption being significant at both the 5% and 1% confidence level. In contrast, standard SOE models that rely on GHH preferences overestimate the volatility of consumption and the resulting standard deviation of consumption is thus significant only at the 1% confidence level. Thus, indivisible labor together with nonseparable preferences helps to generate consumption volatility more in line with the data. Lastly, the volatility of output and total hours are better matched with indivisible labor, both are now significant at the 1% level of significance.\footnote{The standard SOE model with GHH preferences is unable to generate volatility of hours that is statistically significant at the 5% or 1% level. However, it is able to obtain volatility of output that is significant at the 1% level of confidence.}

Figure 3 shows the impulse response functions of output, consumption and labor to a positive technology shock for the case with divisibilities and indivisibilities in labor respectively. The first panel shows the initial rise in consumption in the indivisible labor
model to be more than two times as high as with divisible labor. Subsequently, consumption falls in the former case, while it continues to rise for over a year with indivisible labor. Interestingly, the dynamic response in consumption in the indivisible labor model also obtains in the standard SOE model with GHH preferences. The half-life of consumption in the divisible labor model is close to 50 periods (i.e. quarters), which is twice as high as compared to the indivisible labor model.\textsuperscript{16} Hence, consumption is less persistent when labor is indivisible, which confirms the findings in table 1. The responses in labor and output are qualitatively similar. The initial response in labor is about 80\% higher with indivisible labor as compared to divisible, which transfers into a rise in output of 30\%. The half life of both labor and output is same under both labor market specifications, with labor’s half life being about 2.5 years and that of output being close to 4.5 years. Thus, the persistence of labor and output remains highly unchanged when indivisible labor is introduced.

Next, indivisible labor with non-GHH obtains a negative correlation between output and the trade balance to output ratio that is consistent with the data. Since consumption is no longer excessively smoothed out with involuntary employment, the trade balance falls when the economy is subject to a positive productivity shock to keep the income identity in a balance. As indicated in Table 1, the correlation between output and the trade balance to output ratio falls from 0.986 to –0.343, where the latter is significant at the 1\% level.\textsuperscript{17} Hence, indivisible labor leads to business cycle dynamics in a SOE model with standard preferences that have previously been argued to be impossible to obtain, and moreover match the Canadian data.

\textsuperscript{16} Half-life is defined as the number of periods (quarters) it takes for the response in a variable to fall by half relative to the initial response.
\textsuperscript{17} The correlation between output and the current account to output ratio behaves similarly.
The correlation of output with hours is largely unchanged across models, however unlike the unity correlation implied by GHH preferences, the correlation is slightly less than one. Similarly, the correlations between output and consumption and investment are both less than one, however they remain too high even with labor being indivisible.\textsuperscript{18}

Lastly, the autocorrelations of the model are similar to the standard SOE model (see Schmitt-Grohe and Uribe (2003)), where the model lacks persistence. Letendre (2004) introduces consumption habit and variable capital utilization and finds that the persistence of the model is improved upon. Similar results obtain in Guo and Janko (2007) who introduce intertemporal labor supply into the GHH preferences together with variable capital utilization.

\textbf{4.2 Sensitivity Analysis}

Table 2 reports moments for the indivisible labor model when the relative risk aversion parameter ($\sigma = \text{sigma}$) is set equal to 1 and 3. The former implies a log-log utility function as in Hansen (1985) that yields the same level of consumption for employed as well as unemployed. All other parameters are calibrated as in the $\sigma$ equal to 2 case.\textsuperscript{19} With a rise in the relative risk aversion coefficient the volatility of output, consumption and total hours rises. With $\sigma$ equal to 3, both consumption and labor of employed rises in the presence of a positive technology shock, thus both consumption and labor rise. A rise in labor in turn causes the standard deviation of output to rise. With $\sigma$ equal to 1, the utility function is log-log, hence the risk sharing condition equates consumption of employed to that of unemployed and the additional mechanism via which labor alters

\textsuperscript{18} As shown by Mendoza (1991), Letendre (2004), Letendre and Luo (2007), and Guo and Janko (2007) among others, the correlations of consumption and investment with output are equal to unity in the standard SOE model common in the literature.

\textsuperscript{19} $\sigma$ equal to 2 is included in table 2 for comparison purposes.
consumption (Eq. (6)) is not present. Thus, the volatility of consumption is low and statistically insignificant, as is the standard deviation of total hours.

Figure 4 shows the impulse response functions of output, consumption and hours to a positive change in technology, as the relative risk aversion coefficient rises. The standard deviation findings in table 2 are confirmed. When $\sigma$ equals 1, consumption rises only slightly in response to a shock as do total hours. Thus considering indivisible labor alone is not enough to generate a high response in hours; the relative risk aversion coefficient plays an important role. As $\sigma$ rises the immediate response in consumption rises much more and consumption is no longer hump-shaped as in the log-log utility case. The rises in labor hours contribute to the rise in consumption when $\sigma$ is greater than 1. The increase in labor hours effects output similarly.

The impulse responses in Figure 4, show the response of consumption, output and hours to have very similar dynamic behavior and this corresponds to the findings of high correlations of consumption and hours with output. However, the correlations remain high irrespective of the value of $\sigma$. The findings are altered when considering the correlation between output and the trade balance. With log-log utility the correlation is procyclical and close to 1. However, as $\sigma$ rises, the correlation is negative and rising. Overall, the performance of the log-log model is poor, while the performance of the model with $\sigma$ set to 2 and 3 is improved, with only slight differences arising between the two latter specifications.
5. CONCLUSION

Since the seminal paper by Mendoza (1991), the SOE literature makes use of GHH preferences in order to match business cycle properties of the trade balance and consumption. Alternative preference specification, such as the general preferences utilized by King, Plosser and Rebelo (1988) that yield improvements on the labor market side, have to date been argued to be unsuccessful in obtaining countercyclical trade balance and high volatility of consumption found in small open economies such as Canada. This paper revisits the use of general preferences and finds that when combined with indivisible labor, this model is successful in replicating the Canadian economy with respect to the trade balance, consumption and labor hours (as long as the relative risk aversion parameter is greater than one). With indivisible labor, total hours adjust along the extensive margin, which as seen in the data, is relatively more important in Canada than the intensive margin in explaining total hours and output. More importantly, the volatility of consumption rises, yielding a countercyclical trade balance. Hence, this paper demonstrates that the reliance on GHH preferences in the SOE literature is unnecessary, and for the first time incorporates involuntary unemployment into a small open economy model.
References


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FIGURE 1
Total Hours, Employment and Hours per Worker:
HP Filtered
FIGURE 2
Output, Employment and Hours per Worker: HP Filtered
FIGURE 3
Impulse Response Functions: Divisible vs. Indivisible Labor

Consumption

Labor

Output
FIGURE 4
Sensitivity Analysis to the Relative Risk Aversion Coefficient

Consumption

Labor

Output