Financial Market Integration, Costs of Adjusting Hours Worked and Monetary Policy

M. ALPER ÇENESIZ*;‡ – CHRISTIAN PIERDZIOCH*,†

Based on a dynamic stochastic general equilibrium model featuring a labour-market friction in the form of costs of adjusting hours, we analyse how financial market integration affects the propagation of monetary policy in an open economy. The main result of our analysis is that costs of adjusting hours worked substantially dampen the increase in the effect of monetary policy on output and hours worked brought about by financial market integration.


1. Introduction

International financial markets tend to quickly adjust to macroeconomic developments. Adjustment processes in labour markets, in contrast, are not costless and usually take time. In view of the ongoing international integration of financial markets, the question arises whether this asymmetry has implications for the propagation of monetary policy in an open economy. This is a highly relevant question given that results of recent research on macroeconomic dynamic general equilibrium modelling suggest that labour market frictions may indeed have far-reaching implications for the propagation of monetary policy. In light of these recent results, many researchers have started to extend dynamic general equilibrium models to incorporate various labour market frictions. Search frictions have received considerable attention. Merz (1995) and Andolfatto (1996) were among the first to study search frictions in real business cycle model. The implications of search frictions in labour markets for monetary dynamic

*Centro de Economia e Finanças da Universidade do Porto (CEF.UP), FEP, R.Roberto Frias, Porto, Portugal
†Universitaet des Saarlandes, Saarbruecken, Germany
‡Corresponding author: M. Alper Çenesiz, Centro de Economia e Finanças da Universidade do Porto (CEF.UP), FEP, R.Roberto Frias, 4200-464, Porto, Portugal. Tel: +351-22-557-1100 Fax: +351-22-550-5050. E-mail: acenesiz@fep.up.pt
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general equilibrium modelling have been explored by Walsh (2005), Trigari (2009) and Blanchard and Gali (2010) to name just a few.

Our paper contributes to recent research on the implications of labour market frictions for the propagation of monetary policy in dynamic general equilibrium models. To incorporate slow and costly adjustment processes in labour markets into an otherwise standard open-economy dynamic general equilibrium model, however, we do not use the type of search frictions that have been popular in recent research. Integrating a search friction into an otherwise standard open-economy dynamic general equilibrium model typically results in a relatively advanced and complex model structure (Çesay and Pierdzioch, 2009). To scale down the complexity of our model and, at the same time, to construct a model that generates rich macroeconomic dynamics, we considered a labour market friction that comes in the form of costs of adjusting hours worked. Such adjustment costs represent in an efficient and stylized manner costs such as recruiting costs, training costs and costs of reorganizing family life and child care. Adjustment costs similar to the ones we analyse in this paper have been studied by, for example, Sargent (1978) and Hamermesh (1989) and others.

We incorporated costs of adjusting hours worked into a dynamic stochastic general equilibrium open-economy model of the type that has been popularized by Obstfeld and Rogoff (1995). The Obstfeld–Rogoff model has recently been extended by many authors to study the implications of the structure and the integration of financial markets for macroeconomic dynamics (Sutherland, 1996; Senay, 1998; Betts and Devereux, 2001 and others). These authors, however, have not addressed the question of how financial market integration affects the propagation of monetary policy when adjustment processes in the labour market are costly and time consuming. We studied the implications of costs for adjusting hours worked in a version of the prototype Obstfeld–Rogoff model studied by Betts and Devereux (2001). Their model features pricing-to-market of firms and, thereby, renders it possible, as in Senay (1998), to simultaneously account for the effects of both financial market integration and goods market segmentation on the propagation of monetary policy.

The main result of our analysis is that costs of adjusting hours worked substantially dampen the increase in the effects of monetary policy on output under financial market integration that has been reported in earlier literature. We measured the effects of monetary policy in terms of the unconditional standard deviations of, for example, output, hours worked and other key macroeconomic variables. Our main result extends and qualifies the results on the link between monetary policy and financial market integration that have been reported by Sutherland (1996) and Senay (1998). They have shown that the effects of monetary policy on output should increase as financial markets become more integrated. The main result of our analysis indicates that the magnitude of this increase should
crucially depend upon the structure of the labour market. The importance of the structure of the labour market for the propagation of macroeconomic policies in open economies has also been emphasized in important earlier research based on the classic Mundell–Fleming model (Sachs, 1980). Our research complements this earlier research in that we derive our main result from a dynamic stochastic general equilibrium model featuring a fully articulated microeconomic foundation.

We organize the remainder of this paper as follows. In Section 2, we lay out the model we used to analyse the link between financial market integration, costs of adjusting hours worked and monetary policy. Because our model builds on the model developed by Betts and Devereux (2001), our discussion can be relatively brief. In Section 3, we report the results of numerical simulations of our model. In Section 4, we offer some concluding remarks. At the end of the paper, we present the equations of the model in detail (Appendix).

2. The Model

The world consists of two countries, both populated by a continuum of infinitely lived, internationally immobile, rational households with identical preferences. Households own the firms of the country in which they reside. Firms sell their goods in a monopolistically competitive goods market. Some firms set the prices of their goods in the currency of the country in which they reside. Others set the prices of their goods in the currency of their customers and, thus, follow a pricing-to-market (PTM) strategy (Betts and Devereux, 2001).

2.1. Households

The expected discounted lifetime utility of a representative household is given by

\[
U_t(j) = E_t \sum_{s=t}^{\infty} \beta^{s-t} \left[ \log \left( C_s(j) - h C_{s-1}^A \right) + \frac{\chi}{1 - \varepsilon} \left( \frac{M_s(j)}{P_s} \right)^{1-\varepsilon} - \frac{1}{1 + \phi} N_t^{1+\phi}(j) \right]
\]

with \(0 < \beta < 1, \chi > 0, \varepsilon > 0, 0 \leq h < 1, \phi \geq 0\) and \(j \in (0, n]\), where \(n \in (0, 1)\) denotes the size of the domestic country. \(E_t\) denotes the conditional expectations operator, \(N_t\) denotes hours worked, \(M_t/P_t\) denotes real balances and \(C_t\) denotes a real consumption index defined as the usual CES aggregator over differentiated goods \(c_t(z), z \in (0, 1)\), with elasticity...
of substitution given by $\theta > 1$. Aggregate (per capita) consumption, $C^A_t$, captures a ‘catching up with the Joneses’ effect in households’ preferences. The consumer price index, $P_t$, is defined as

$$P_t = \left[ \int_0^n p_t(z)^{1-\theta} \, dz + \int_n^{n+(1-n)\xi} q_t(z^*)^{1-\theta} \, dz + \int_{n+(1-n)\xi}^1 (S_t p_t^*(z^*))^{1-\theta} \, dz \right]^{1/(1-\theta)}$$

where $\xi$ denotes the proportion of firms that follow a PTM strategy, $p_t(z)$ denotes the domestic currency price of a domestically produced good, $q_t(z^*)$ denotes the domestic currency price of a foreign PTM good, $S_t$ denotes the nominal exchange rate and $p_t^*(z^*)$ denotes the foreign currency price of a foreign non-PTM good.

A household’s budget constraint is given by

$$\frac{D_t(j) + M_t(j)}{P_t} + C_t(j) + I_t(j) + AC^K_t(j) + AC^N_t(j) = R_{t-1} D_{t-1}(j) + M_{t-1}(j)$$

$$= \frac{R_t K_t(j) + \tilde{\Pi}_t + T_t}{P_t}$$

where $D_t$ denotes the quantity of domestic nominal riskless one-period bonds, $R_t$ denotes the gross nominal interest rate on bonds, $R^K_t$ denotes the real rental rate of capital, $T_t$ denotes real lump-sum transfers from the government, $w_t$ denotes the real wage rate, $\tilde{\Pi}_t$ denotes the real profit income and $I_t$ denotes real investment (constructed in the same way as the consumption index, $C_t$).

The term $AC^N_t$ denotes costs of adjusting hours worked. Various functional forms have been used in the literature to model costs of adjusting hours worked. For simplicity, we assume that the costs are quadratic. An analysis of various functional forms of costs of adjusting hours worked, including the case of quadratic costs, can be found in Adda and Cooper (2003). The costs of adjusting hours worked are given by

$$AC^N_t(j) = \frac{v}{2} \frac{(N_t(j) - N_{t-1}(j))^2}{N_{t-1}(j)}$$

where $v \geq 0$. To retain symmetry, we assume that capital adjustment costs, $AC^K_t$, are also quadratic. The law of motion of households’ capital stock, $K_t(j)$, and capital adjustment costs, $AC^K_t(j)$, are given by

$$I_t(j) = K_{t+1}(j) - (1 - \delta) K_t(j)$$

$$AC^K_t(j) = \frac{\psi}{2} \frac{(K_{t+1}(j) - K_t(j))^2}{K_t(j)}$$

where $0 \leq \delta \leq 1$ and $\psi \geq 0$. 

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We let $\lambda_t$ denote the Lagrange multiplier on the households’ budget constraint. The first-order conditions for the households’ maximization problem can be written as

$$ (C_t - hC_{t-1}^A)^{-1} = \lambda_t $$

(7)

$$ \chi \left( \frac{M_t}{P_t} \right) = \lambda_t - \beta E_t \left[ \frac{\lambda_{t+1}}{\pi_{t+1}} \right] $$

(8)

$$ \lambda_t = \beta R_tE_t \left[ \frac{\lambda_{t+1}}{\pi_{t+1}} \right] $$

(9)

$$ \lambda_t + \psi \lambda_t \frac{K_{t+1} - K_t}{K_t} = \beta E_t \lambda_{t+1} \left( R_{t+1}^K + (1 - \delta) \right) $$

$$ + \frac{\psi}{2} \beta E_t \lambda_{t+1} \frac{K_{t+2}^2 - K_{t+1}^2}{K_{t+1}^2} $$

(10)

$$ N_t^\phi + \nu \lambda_t \frac{N_t - N_{t-1}}{N_{t-1}} = \lambda_t w_t + \frac{\nu}{2} \beta E_t \lambda_{t+1} \frac{N_{t+1}^2 - N_{t}^2}{N_{t}^2} $$

(11)

where $\pi_t$ denotes the gross rate of inflation, $\pi_t = P_t/P_{t-1}$, and we have dropped the household index, $j$. In addition, the usual transversality condition applies.

2.2. Firms

The production function of a firm that produces good $z$ is given by

$$ y_t(z) = A_t K_t(z)^\alpha N_t(z)^{1-\alpha} $$

(12)

where $A_t$ denotes an aggregate productivity shock. Denoting real marginal costs by $mc_t$, cost-minimization implies

$$ w_t(z) = (1 - \alpha) mc_t(z) y_t(z) / N_t(z) $$

and

$$ R_t^K(z) = \alpha mc_t(z) y_t(z) / K_t(z). $$

(13)

(14)

Because of monopolistic competition in the goods market, a firm can set the price of its good to maximize profits subject to demand functions. In the case of a domestic PTM firm, the demand functions are given by

$$ y_t^D(z) = (p_t(z)/P_t)^{-\theta} Q_t $$

(15)
where $q_t^*(z)$ denotes the foreign-currency price of a domestic PTM good, $y_t^D(z)$ and $y_t^F(z)$ denote the demand at home and abroad, and $Q_t = n(C_t + I_t + AC_t^N + AC_t^K)$ and $Q_t^* = (1 - n)(C_t^* + I_t^* + (AC_t^N)^* + (AC_t^K)^*)$.

In the case of a domestic non-PTM firm, the demand function is given by

$$y_t^N(z) = \frac{(P_t(z)/P_t)}{\theta Q_t} + \frac{(P_t(z)/(S_t P_t^*))^{\theta} Q_t^*}$$

where $y_t^N$ denotes the world demand of a domestic non-PTM firm.

As in Calvo (1983), the firm cannot revise the price of its good in any given period of time with probability $0 < \gamma < 1$. Therefore, a PTM firm sets the current domestic-currency and foreign-currency prices of the product, $p_t(z)$ and $q_t^*(z)$, so as to maximize the expected discounted present value of profits. The result is

$$\frac{p_t(z)}{P_t} = \frac{\theta}{\theta - 1} \frac{E_t \sum_{s=t}^{\infty} \gamma^{s-l} R_{t,s} Q_s (P_s/P_t)^{\theta} mcs}{E_t \sum_{s=t}^{\infty} \gamma^{s-l} R_{t,s} Q_s (P_s/P_t)^{\theta-1}}$$

$$\frac{q_t^*(z)}{P_t^*} = \frac{\theta}{\theta - 1} \frac{E_t \sum_{s=t}^{\infty} \gamma^{s-l} R_{t,s} Q_s^* (P_s^*/P_t^*)^{\theta} mcs}{E_t \sum_{s=t}^{\infty} \gamma^{s-l} R_{t,s} Q_s^* (P_s^*/P_t^*)^{\theta-1} e_s}$$

where $R_{t,s} = \prod_{j=s}^{t} R_{j-1}$, $R_{t,t} = 1$, and $e_t$ denotes the real exchange rate defined as $e_t = \frac{S_t P_t^*}{P_t}$. Similar expressions can be derived for the profit-maximizing prices, $q_t(z^*)$ and $p_t^*(z^*)$, set by foreign PTM firms and by non-PTM firms.

2.3. International Financial Markets

To model the structure of international financial markets, we considered two cases. First, we considered the case of a world economy in which agents can trade in integrated financial markets for one-period nominal bonds. For simplicity, we assumed that domestic households invest in a home-currency denominated nominal bond, and that foreign households invest in a foreign-currency denominated nominal bond and a home-currency denominated nominal bond. This assumption implies that Equation (3) holds, irrespective of the degree of the structure of international financial markets. In addition, in the case of an integrated international
bond market, the condition of uncovered interest-rate parity holds. In this case, the market-clearing condition for the home-currency denominated nominal bond is given by
\[
\int_j D^i_j \, dj + \int_j D^{i*}_j \, dj = 0 \tag{20}
\]
Secondly, we considered the case of a world economy in which markets for trade in international assets do not exist (Cole and Obstfeld, 1991; Heathcote and Perri, 2002). The market-clearing conditions for the bond markets in this case of financial autarky are given by
\[
\int_j D^i_j \, dj = 0 \tag{21}
\]
and
\[
\int_j F^{i*}_j \, dj = 0 \tag{22}
\]
where \(F^{i*}_j\) denotes the foreign-currency denominated bond.

2.4. The Government Sector

The government sector consists of a fiscal authority and a central bank. The budget constraint of the fiscal authority is given by
\[
P_t T_t = M_t - M_{t-1} \tag{23}
\]
The central bank controls the money supply, where the money supply grows at a gross rate of \(m_t\). Money supply evolves according to
\[
\frac{M_t}{P_t} = \frac{m_t M_{t-1}}{\pi_t P_{t-1}} \tag{24}
\]
In Section 3, we shall also analyse an interest-rate rule. Following Taylor (1993), it has become popular in recent years to describe monetary policy in terms of interest-rate rules.

2.5. Solution and Calibration of the Model

We used the algorithm developed by McCallum (1998) and Klein (2000) to solve our model. To this end, we log-linearized our model around a symmetric flexible-price deterministic steady state in which bond holdings are zero. We calibrated the log-linearized model to match the moments of postwar, quarterly U.S. data as reported by Dotsey and Duarte (2008). Dotsey and Duarte (2008) report moments for the US (as the home country) and a composite of its major trading partners (as
Table 1: Calibrated Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country size</td>
<td>$n = 0.5$</td>
</tr>
<tr>
<td>Households’ subjective discount factor</td>
<td>$\beta = 0.99$</td>
</tr>
<tr>
<td>Semi-interest elasticity of money demand</td>
<td>$\varepsilon = 9$</td>
</tr>
<tr>
<td>'Catching-up with the Joneses’ parameter</td>
<td>$h = 0.8$</td>
</tr>
<tr>
<td>Labour supply elasticity</td>
<td>$1/\phi = 1$</td>
</tr>
<tr>
<td>Demand elasticity</td>
<td>$\theta = 11$</td>
</tr>
<tr>
<td>Depreciation rate</td>
<td>$\delta = 0.024$</td>
</tr>
<tr>
<td>Capital share in the production function</td>
<td>$\alpha = 0.36$</td>
</tr>
<tr>
<td>Probability of not adjusting prices</td>
<td>$\gamma = 0.75$</td>
</tr>
<tr>
<td>Capital adjustment costs</td>
<td>$\psi = 21.5$</td>
</tr>
<tr>
<td>Labour adjustment costs</td>
<td>$\nu = 3.5$</td>
</tr>
<tr>
<td>Proportion of PTM firms</td>
<td>$\xi = 0.95$</td>
</tr>
<tr>
<td>Risk premium</td>
<td>$\Psi = 0.004$</td>
</tr>
</tbody>
</table>

the foreign country), where the sample period is 1973:Q1–2004:Q3. Table 1 summarizes the calibrated parameters.

Households’ discount factor assumes the value $\beta = 0.99$. As in Sutherland (1996) and Senay (1998), the semi-interest elasticity of money demand assumes a value of $\varepsilon = 9$. The ‘catching-up with the Joneses’ effect in households’ preferences is captured by the parameter $h = 0.8$ (Ljungqvist and Uhlig, 2000). The domestic and foreign countries are of equal size ($n = 0.5$). The parameter that governs the magnitude of the costs of adjusting hours worked is given by $\nu = 3.5$ in our baseline calibration, which produces a standard deviation of consumption relative to the standard deviation of output matching its counterpart in US data. Our calibration is in the middle range of estimates of this parameter reported in the empirical literature. For example, based on a labour adjustment cost function that slightly differs from the one we use, Ambler et al. (2003) report an estimate of 7.92. Hall (2004), in contrast, reports estimates that are close to zero. Cooper and Willis (2009) analyse an asymmetric adjustment cost function that features different parameters, $\nu$, for positive and negative labour adjustments. The average of their estimates is 3.81. Given the wide range of parameter values reported in the empirical literature, we analyse the range $\nu \in [0, 40]$ in our robustness checks in Section 3.3.

With regard to the elasticity of substitution between differentiated goods, the steady-state mark up assumes a value of 10 per cent, implying $\theta = 11$. The annual depreciation rate is 10 per cent, implying $\delta = 0.024$. The capital share parameter in the production function assumes the value $\alpha = 0.36$, as is standard in the literature. The average delay between price adjustments is four periods ($\gamma = 0.75$). As regards capital adjustment costs, we assumed $\psi = 21.5$, a value in line with the empirical estimates reported by Bergin (2006). Bergin’s empirical estimates further imply that the proportion of firms that follow a PTM price-setting strategy is relatively large. Accordingly, we assumed $\xi = 0.95$. The proportion of PTM firms,
thus, is relatively large in our benchmark calibration. In Section 3.3, we shall show that our results are robust to changes in the proportion of PTM firms.

With regard to the stochastic processes that describe the dynamics of domestic and foreign productivity, we followed Backus et al. (1992) in specifying the following bivariate autoregressive model:

\[
\begin{bmatrix}
\hat{A}_t \\
\hat{A}_t^*
\end{bmatrix} =
\begin{bmatrix}
0.906 & 0.088 \\
0.088 & 0.906
\end{bmatrix}
\begin{bmatrix}
\hat{A}_{t-1} \\
\hat{A}_{t-1}^*
\end{bmatrix} +
\begin{bmatrix}
\varepsilon_{A,t} \\
\varepsilon_{A,t}^*
\end{bmatrix}
\]

(25)

where a hat denotes deviations of a variable from the steady state. The variances of the disturbance terms are given by \( \text{var} (\varepsilon_{A,t}) = \text{var} (\varepsilon_{A,t}^*) = (0.00852)^2 \). The coefficient of correlation between the disturbance terms, \( \text{corr} (\varepsilon_{A,t}, \varepsilon_{A,t}^*) \), is 0.258.

Following Chari et al. (2002), we calibrated the stochastic processes that describe the dynamics of domestic and foreign monetary shocks

\[
\begin{bmatrix}
\hat{m}_t \\
\hat{m}_t^*
\end{bmatrix} =
\begin{bmatrix}
0.68 & 0 \\
0 & 0.68
\end{bmatrix}
\begin{bmatrix}
\hat{m}_{t-1} \\
\hat{m}_{t-1}^*
\end{bmatrix} +
\begin{bmatrix}
\varepsilon_{m,t} \\
\varepsilon_{m,t}^*
\end{bmatrix}
\]

(26)

and set \( \text{corr} (\varepsilon_{m,t}, \varepsilon_{m,t}^*) = 0.5 \). The variances of the disturbance terms are given by \( \text{var} (\varepsilon_{m,t}) = \text{var} (\varepsilon_{m,t}^*) = (0.0115)^2 \), as implied by US data.

It is well known that in dynamic general equilibrium open-economy models with integrated, but incomplete financial markets the problem arises that the steady state around which the model is being log-linearized is not stationary because of the bond accumulation induced by macroeconomic shocks. Various modelling devices have been advocated in earlier literature to resolve this problem. To induce stationarity of the steady state of the version of our model that features an integrated international bond market, we extended the condition of uncovered interest rate parity to incorporate a risk premium (Schmitt-Grohé and Uribe, 2003). The linearized risk premium is proportional to the holdings in bonds, \( \Psi \hat{D}_t + \hat{u}_t \), where \( \hat{u}_t \) denotes a shock that captures deviations from uncovered interest rate parity. We set \( \Psi = 0.004 \), based on the empirical estimates reported by Bergin (2006), and assumed that the risk premium shock follows a first-order autoregressive process of the format

\[
\hat{u}_t = \rho \hat{u}_{t-1} + \varepsilon_{u,t}
\]

(27)

Drawing on the estimates of Kollmann (2005), we set \( \rho = 0.5 \) and \( \text{var} (\varepsilon_{u,t}) = (0.033)^2 \). McCallum and Nelson (1999) use similar values.

With this baseline calibration, our benchmark model featuring adjustment costs for hours worked implies a value of 1.87% for the standard deviation of output. In US data, the standard deviation of output is 1.8%.
3. Simulation Results

We present our simulation results in three steps. In a first step, we present impulse response functions to graphically illustrate the mechanics of our model. In a second step, we report results of stochastic simulations to show that the model implies moments (standard deviations, correlations) that approximate reasonably well moments implied by real-world data. In a third step, we report the results of various robustness checks.

3.1. Impulse Response Functions

The impulse response functions shown in Figure 1 describe the dynamics of key macroeconomic variables in the aftermath of a one-time unit shock to the growth rate of money supply in the domestic country. To make the shock purely orthogonal, we set corr \((\epsilon_{m,t}, \epsilon_{m,t}^*) = 0\). All variables are measured in terms of percentage deviations from the steady state. We computed impulse response functions for four cases. Case 1 represents a model featuring costs of adjusting hours worked and financial market integration. Case 2 represents a model featuring costs of adjusting hours worked and financial autarky. Case 3 represents a model featuring no costs of adjusting hours worked \((\nu = 0)\) and financial market integration. Finally, Case 4 represents a model featuring no costs of adjusting hours worked and financial autarky.

The liquidity effect of monetary policy results in a decrease in the real interest rate and an increase in investment. The decrease in the real interest rate goes hand in hand with a depreciation of the real exchange rate. Consumption also increases, but only gradually because the ‘catching-up with the Joneses’ effect in households’ preferences requires a gradual adjustment of consumption. The increase in the demand for goods implies that a monetary shock results in an increase in output and hours worked. The effects of a monetary shock on output and hours worked increase in the short run as we move from the case of financial autarky to the case of financial market integration. In the medium run, financial market integration dampens the effects of monetary policy on output and hours worked. The short-run effects of monetary policy on consumption, investment and the real interest rate are hardly affected by switching from financial autarky to financial market integration. The impulse response functions further illustrate that the assumption of costs of adjusting hours worked implies that the difference between the short-run effect of monetary policy on output and hours worked under financial market integration and under financial autarky substantially decreases. Switching from financial autarky to financial market integration, thus, has a much smaller effect on the propagation of monetary policy in the short run.
Figure 1. Impulse Response Functions for a Monetary Shock

Note: The figure plots the responses of domestic variables to a unit (transitory and autoregressive) domestic monetary policy shock (see Equation 26). To make the shock purely orthogonal, we set $\text{corr}(\epsilon_{m,t}, \epsilon_{m,t}^*) = 0$. Case 1: costs for adjusting hours worked and financial market integration. Case 2: costs for adjusting hours worked and financial autarky. Case 3: no costs for adjusting hours worked and financial market integration. Case 4: no costs for adjusting hours worked and financial autarky. All variables are measured as percentage deviations from the steady state.
The economic intuition behind this result is that costs of adjusting hours worked imply that households seek to smooth hours over time. Because the short-run effect of monetary policy on output and hours worked is larger under financial market integration than under financial autarky, the incentive to smooth hours worked is also larger under financial market integration. Under financial market integration, costs of adjusting hours worked, thus, have a stronger dampening effect on the propagation of monetary policy than under financial autarky. This dampening effect is absent from the model if we set \( \nu = 0 \).

3.2. Stochastic Simulations

Stochastic simulations render it possible to check whether the model does a reasonably good job in explaining real-world business-cycle fluctuations. Specifically, our stochastic simulations shed light on the question whether extending our model to incorporate costs for adjusting hours worked brings the (unconditional) standard deviations and the (unconditional) correlations of key macroeconomic variables implied by our dynamic general equilibrium model closer to standard deviations and correlations observed in real-world data.

Table 2 summarizes the simulation results. The table shows three sets of results. First, the table shows standard deviations (relative to GDP) and correlations of important macroeconomic variables observed in HP-filtered data for the United States (standard deviations and autocorrelations) and an aggregate composed of a group other major countries (cross correlations). The group of other countries includes Canada, Japan and 15 European countries. The standard deviations and correlations are from Dotsey and Duarte (2008, Table 2), who used HP-filtered quarterly data for the period 1973:Q1−2004:Q3 to compute these moments. Secondly, Table 2 shows results of stochastic simulations of our benchmark model, where we report simulation results for two scenarios. In the first scenario, costs of adjusting hours worked are as given in Table 1. In the second scenario, costs of adjusting hours worked are zero. Thirdly, Table 2 shows results of stochastic simulations of our benchmark model, where we replaced the money supply rule given in Equation (26) with a Taylor rule of the format

\[
\hat{R}_t = \mu_1 \hat{R}_{t-1} + (1 - \mu_1) \left( \mu_2 \hat{y}_t + \mu_3 \Delta \hat{P}_t \right) + \varepsilon_{R,t}
\]

where \( \Delta \) denotes the first-difference operator. The same Taylor rule applies in the case of the foreign country. We set \( \mu_1 = 0.9, \mu_2 = 0.05 \) and \( \mu_3 = 1.5 \), as is standard in earlier literature. We set \( \text{var} (\varepsilon_{R,t}) = \text{var} (\varepsilon_{R,t}^*) = (0.013)^2 \) and \( \text{corr} (\varepsilon_{R,t}, \varepsilon_{R,t}^*) = 0.5 \) to ensure that the standard deviation of output implied by this version of the model is equal to the one implied by the benchmark model. Again, we present results for a scenario in which costs
of adjusting hours worked are as given in Table 1, and another scenario in which costs of adjusting hours worked are zero.

Several observations emerge from Table 2. One observation is that the results of the stochastic simulations of the model featuring a Taylor rule are similar to the simulation results for the model featuring the money supply rule given in Equation (26). Our results, thus, are robust to the way we specify monetary policy. Another observation is that the versions of our model featuring adjustment costs for hours worked yield standard deviations (relative to output) that are much closer to the standard deviations observed in the data than the standard deviations that we obtained when we dropped costs for adjusting hours worked. It follows that costs of adjusting hours worked improve the empirical fit of our model as far as standard deviations are concerned. Yet another improvement brought about by accounting for adjustment costs for hours worked is that the autocorrelation of output implied by the simulated model better matches the autocorrelation of US GDP. The autocorrelations of nominal and real exchange rates implied by the simulated model, however, are only half as large as the autocorrelation observed in the data. This is the ‘persistence puzzle’ that has been the subject of much significant recent research (Chari

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et al., 2002). The ‘persistence puzzle’ is invariant to adjustment costs for hours worked.

One can also observe from the results documented in Table 2 that, despite the persistence puzzle, the model performs well in terms of its empirical fit with regard to the cross-correlation of the real exchange rate and the nominal exchange rate. The cross-correlation of the real exchange rate and output implied by the model is higher than the empirical one, but costs of adjusting hours worked bring the cross-correlation implied by the simulated model substantially closer to the one observed in the data. Another observation is that the cross-correlation of the real exchange rate with relative (cross-country) consumption implied by the model is positive, whereas the cross-correlation observed in the data is negative. The model featuring a Taylor rule fares a bit better in this respect.

Regarding cross-correlations between domestic and foreign output, it is evident from the results of the stochastic simulations that extending our model to incorporate costs of adjusting hours worked leads to a significant improvement in the empirical fit of our model. Whereas both the benchmark model and the Taylor-rule model that do not feature costs of adjustment of hours worked predict a negative cross-correlation, both models yield a positive cross-correlation when costs of adjusting hours worked are taken into account. This improvement comes at the cost that the simulated model featuring adjustment costs for hours worked implies lower cross-country correlations of consumption and investment than observed in the data.

3.3. Robustness Checks

To analyse the effects of costs for adjusting hours worked for the propagation of monetary policy in more detail, we set the variance of productivity shocks, risk premium shocks and foreign monetary shocks to zero. We then computed the ratio of the unconditional standard deviation of a variable under financial market integration to the corresponding unconditional standard deviation under financial autarky. To this end, we computed the following ratio:

\[
\Omega(\hat{x}) = \frac{V_{\hat{x},FI}}{V_{\hat{x},FA}}
\]

where \(V_{\hat{x}}\) denotes the unconditional standard deviation of macroeconomic variable \(\hat{x}\), and \(FI\) (\(FA\)) denotes the case of financial market integration (financial autarky). We computed the ratio of standard deviations, \(\Omega\), for various specifications of our model. In a first step, we used the baseline calibration (with and without costs of adjusting hours worked) to compute the ratios of standard deviations of output, consumption, investment, hours worked, the real exchange rate and the inflation rate. In a second step, we
changed the calibrations of various important parameters of our model as follows:

(1) We reduced the probability of adjusting goods prices from $\gamma = 0.75$ in the baseline calibration to $\gamma = 0.25$. The results for $\gamma = 0.25$ shed light on the question whether our results are robust to the degree of nominal rigidity in goods prices.

(2) We changed the country size from $n = 0.5$ to $n = 0.25$. Assuming asymmetric country sizes renders it possible to analyse whether country size matters for our simulation results.

(3) We changed the proportion of PTM firms from $\xi = 0.95$ to $\xi = 0.1$. Reducing the proportion of PTM firms makes it possible to check whether our results are robust to a lower degree of goods market segmentation than in the baseline calibration.

(4) We dropped habit formation from households’ preferences by setting $h = 0$. This specification of our model allows the robustness of our results to the extent of consumption smoothing to be analysed.

(5) We simulated the version of our model that features the Taylor rule given in Equation (28). Upon comparing the benchmark model with the Taylor-rule model, we can explore the sensitivity of our simulation results with respect to the specification of monetary policy.

(6) We considered a version of our model in which the costs of adjusting hours worked are asymmetric across countries. To this end, we assumed that the home country features adjustment costs as in the benchmark model and the foreign country features no adjustment costs.

Table 3 summarizes the results. A comparison of the results implied by the benchmark model featuring costs of adjusting hours worked with the results implied by a model that does not feature costs of adjusting hours worked confirms the results of the analysis of the impulse response functions shown in Figure 1. The standard deviations of output and hours worked under financial market integration exceed the respective standard deviations under financial autarky ($\Omega > 1$) where the case of $h = 0$ is the only exception. Costs of adjusting hours worked lead to a substantial reduction of the ratios of standard deviations, $\Omega$.

The effect of costs of adjusting hours worked on the ratio ratio of standard deviations, $\Omega$, in the cases of consumption, investment, the real exchange rate and the inflation rate are relatively small. The dynamics of consumption mainly reflect households’ preference for intertemporal consumption smoothing. The dynamics of investment reflect adjustment costs for capital. The dynamics of the real exchange rate mainly reflect the degree of PTM behaviour of firms. Finally, the dynamics of the inflation rate mainly reflect the extent to which goods price adjust sluggishly over time.
Table 3: Financial Market Integration and Monetary Policy

<table>
<thead>
<tr>
<th></th>
<th>Benchmark $y = 0.25$</th>
<th>$n = 0.25$</th>
<th>$\xi = 0.1$</th>
<th>$h = 0$</th>
<th>Taylor rule</th>
<th>Asymmetric labour markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Output</td>
<td>1.1547</td>
<td>1.1743</td>
<td>1.3130</td>
<td>1.7855</td>
<td>0.9598</td>
<td>1.1831</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.9797</td>
<td>0.8746</td>
<td>0.9801</td>
<td>0.6915</td>
<td>1.0178</td>
<td>0.9993</td>
</tr>
<tr>
<td>Investment</td>
<td>0.9588</td>
<td>0.8179</td>
<td>0.9454</td>
<td>0.6494</td>
<td>1.0184</td>
<td>0.9646</td>
</tr>
<tr>
<td>Hours worked</td>
<td>1.1864</td>
<td>1.2973</td>
<td>1.5312</td>
<td>1.8038</td>
<td>0.9610</td>
<td>1.2116</td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>1.3052</td>
<td>1.2097</td>
<td>1.2996</td>
<td>1.5419</td>
<td>0.9319</td>
<td>1.4358</td>
</tr>
<tr>
<td>Inflation rate</td>
<td>1.0283</td>
<td>1.0319</td>
<td>1.0393</td>
<td>1.2902</td>
<td>0.9852</td>
<td>1.0657</td>
</tr>
<tr>
<td>No AC Output</td>
<td>1.2469</td>
<td>1.5247</td>
<td>1.6117</td>
<td>2.5199</td>
<td>0.9762</td>
<td>1.3193</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.9809</td>
<td>0.8985</td>
<td>0.9821</td>
<td>0.7128</td>
<td>1.0132</td>
<td>0.9977</td>
</tr>
<tr>
<td>Investment</td>
<td>0.9618</td>
<td>0.8648</td>
<td>0.9482</td>
<td>0.6600</td>
<td>1.0118</td>
<td>0.9659</td>
</tr>
<tr>
<td>Hours worked</td>
<td>1.2831</td>
<td>1.6323</td>
<td>1.8756</td>
<td>2.5438</td>
<td>0.9775</td>
<td>1.3510</td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>1.2970</td>
<td>1.1628</td>
<td>1.2909</td>
<td>1.5849</td>
<td>0.9595</td>
<td>1.4270</td>
</tr>
<tr>
<td>Inflation rate</td>
<td>1.0241</td>
<td>1.0252</td>
<td>1.0346</td>
<td>1.3052</td>
<td>0.9880</td>
<td>1.0618</td>
</tr>
</tbody>
</table>

Note: The table reports the ratio, $\Omega$, of unconditional standard deviations under financial integration to that under financial autarky. The shock is a (home) monetary policy shock.

As yet another robustness check, we analysed the ratio of standard deviations, $\Omega$, for a broad range of the parameter that captures the magnitude of costs of adjusting hours worked. Specifically, we varied this parameter in the range $\nu \in [0, 40]$. Figure 2 summarizes the results. The results demonstrate that costs of adjusting hours worked have a large and seizable effect on the ratio of standard deviations, $\Omega$, in the cases of output and hours worked. The ratio of standard deviations, $\Omega$, gets smaller as the parameter $\nu$ increases. In other words, costs of adjusting hours work dampen the effect of financial market integration on the standard deviations of output and hours worked. The ratio of standard deviations is relatively insensitive to variations in the parameter $\nu$ as far as consumption, investment, the real exchange rate, and the inflation rate are concerned.

Finally, it is interesting to contrast the results of varying the costs of adjusting hours worked given in Figure 2 with results that we obtained when we varied adjustment costs for capital, $\psi$. To this end, we present in Figure 3 the ratio of standard deviations, $\Omega$, of output as a function of the adjustment costs for capital, $\psi$. In contrast to adjustment costs for hours worked, adjustment costs for capital increase the ratio, $\Omega$. In other words, while costs of adjusting hours worked dampen the increase in the standard deviation of output due to monetary policy resulting from switching from financial autarky to financial market integration, adjustment costs for capital have the opposite effect. Adjustment costs for capital lower...
Figure 2. Sensitivity to $\nu$.

Note: The horizontal axis measures costs of adjusting hours worked, $\nu$. The vertical axis measures the ratio of standard deviations as in Table 3.
Figure 3. Sensitivity to $\psi$. The horizontal axis measures adjustment costs for capital, $\psi$. The vertical axis measures the ratio of standard deviations as in Table 3.
the standard deviation of investment, implying that hours worked bear the burden of adjustment in case of macroeconomic shocks. As a consequence, higher adjustment costs for capital increase the standard deviation of hours worked for any given level of costs of adjusting hours worked. The result is a higher standard deviation of output.

4. Concluding Remarks

The motivation for our analysis was to show that the effect of financial market integration on the propagation of monetary policy can significantly depend on the structure of the labour market. International financial markets tend to quickly adjust to changes in the stance of monetary policy. The adjustment of labour markets, in contrast, tends to be costly and takes time. We accounted for this asymmetry between financial and labour markets by extending a two-country dynamic stochastic general equilibrium model to include costs of adjusting hours worked. As compared to other, more complex labour-market frictions, costs of adjusting hours worked require only few modifications of standard dynamic general equilibrium open-economy models. The main result of our analysis is that costs of adjusting hours worked substantially dampen the increase in the effect of monetary policy on output and hours worked brought about by financial market integration.

Before general policy-relevant conclusions can be drawn from the type of analysis we have undertaken in this paper, future research should extend our research in various directions. For example, while we have focused on costs of adjusting hours worked, future research might reveal that search frictions or efficiency wages are also important for the way how financial market integration affects the propagation of monetary policy. If this is the case, one could use the results reported by Danthine and Kurmann (2004), Walsh (2005) and others to extend our model to include search frictions or efficiency wages. We hope that our research will set the stage for such extensions.

Finally, it should be mentioned that an implicit assumption underlying our analysis is that the process of financial integration and, more general, the process of ‘globalization’ is invariant to the magnitude of costs of adjusting hours worked. A plausible alternative assumption would be that costs of adjusting hours worked and, thus, labour-market frictions reinforce the process of globalization. At the same time, it is likely that, for example, outsourcing of production activities has become easier in a globalized world. Thereby, globalization may have had a significant effect on costs of adjusting hours worked and other labour-market frictions.
REFERENCES


**Appendix**

Here we briefly present the equations that describe the dynamics of the model featuring integrated financial markets. For the sake of brevity, we only present the equations for the domestic country.
\[
(C_t - hC_{t-1})^{-1} = \lambda_t
\]

(A2) \[
\chi \left( \frac{M_t}{P_t} \right)^{-\epsilon} = \lambda_t - \beta E_t \left[ \frac{\lambda_{t+1}}{\pi_{t+1}} \right]
\]

(A3) \[
\lambda_t = \beta R_tE_t \left[ \frac{\lambda_{t+1}}{\pi_{t+1}} \right]
\]

(A4) \[
\lambda_t + \psi \lambda_t \frac{K_{t+1} - K_t}{K_t} = \beta E_t \lambda_{t+1} \left( R_e^{K+1} + (1 - \delta) \right) + \frac{\psi}{2} \beta E_t \lambda_{t+1} \frac{K_{t+2}^{2} - K_{t+1}^{2}}{K_{t+1}^{2}}
\]

(A5) \[
N_t^\phi + \nu \lambda_t \frac{N_t - N_{t-1}}{N_{t-1}} = \lambda_t w_t + \frac {2} \beta E_t \lambda_{t+1} \frac{N_{t+2}^{2} - N_t^{2}}{N_t^{2}}
\]

(A6) \[
I_t = K_{t+1} - (1 - \delta)K_t
\]

(A7) \[
y_t = \xi (y_t^D + y_t^F) + (1 - \xi) y_t^N
\]

(A8) \[
y_t^D = (r p_t)^{-\theta} Q_t
\]

(A9) \[
y_t^F = (r p_t^F)^{-\theta} Q_t^*
\]

(A10) \[
y_t^N = (r p_t)^{-\theta} (Q_t + e_t^\theta Q_t^*)
\]

(A11) \[
Q_t = n \left( C_t + I_t + \frac{\nu (N_t - N_{t-1})^2}{2 N_{t-1}} + \frac{\psi (K_{t+1} - K_t)^2}{2 K_t} \right)
\]

(A12) \[
y_t = A_t K_t^{\alpha} N_t^{1-\alpha}
\]

(A13) \[
w_t = (1 - \alpha) mc_t y_t / N_t
\]

(A14) \[
R_t^K = \alpha mc_t y_t / K_t
\]
\[ \tilde{r}_{t} = \frac{\theta}{\theta - 1} \frac{E_{t} \sum_{s=t}^{\infty} \gamma^{s-t} R_{t,s} Q_{s} (\pi_{t,s})^{\theta} m_{c,s}}{E_{t} \sum_{s=t}^{\infty} \gamma^{s-t} R_{t,s} Q_{s} (\pi_{t,s})^{\theta - 1}} \]  
(A15)

\[ \tilde{r}_{t}^{F} = \frac{\theta}{\theta - 1} \frac{E_{t} \sum_{s=t}^{\infty} \gamma^{s-t} R_{t,s} Q_{s}^{*} (\pi_{t,s}^{*})^{\theta} m_{c,s}}{E_{t} \sum_{s=t}^{\infty} \gamma^{s-t} R_{t,s} Q_{s}^{*} (\pi_{t,s}^{*})^{\theta - 1} e_{s}} \]  
(A16)

\[ n(r_{t})^{1-\theta} + (1 - n)\xi(r_{t}^{*F})^{1-\theta} + (1 - (n + (1 - n)\xi)) (e_{t} r_{t}^{*})^{1-\theta} = 1 \]  
(A17)

\[ (r_{t})^{1-\theta} = \gamma (r_{t-1})^{1-\theta} (\pi_{t})^{\theta - 1} + (1 - \gamma) (\tilde{r}_{t})^{1-\theta} \]  
(A18)

\[ (r_{t}^{F})^{1-\theta} = \gamma (r_{t-1}^{F})^{1-\theta} (\pi_{t}^{*})^{\theta - 1} + (1 - \gamma) (\tilde{r}_{t}^{F})^{1-\theta} \]  
(A19)

\[ \frac{M_{t}}{P_{t}} = \frac{m_{t}}{\pi_{t}} \frac{M_{t-1}}{P_{t-1}} \]  
(A20)

\[ \log A_{t} = \rho_{A} \log A_{t-1} + \rho_{A^{*}} \log A_{t-1}^{*} + \varepsilon_{A,t} \]  
(A21)

\[ \log m_{t} = \rho_{m} \log m_{t-1} + \varepsilon_{m,t} \]  
(A22)

\[ \log u_{t} = \rho_{u} \log u_{t-1} + \varepsilon_{u,t} \]  
(A23)

\[ \frac{D_{t}}{P_{t}} + C_{t} + I_{t} - \frac{v}{2} \left( \frac{N_{t} - N_{t-1}}{N_{t-1}} \right)^{2} + \frac{\psi}{2} \left( \frac{K_{t+1} - K_{t}}{K_{t}} \right)^{2} \]  
\[ = \frac{R_{t-1} D_{t-1}}{P_{t}} + (\xi y_{t}^{D} + (1 - \xi) y_{t}^{N}) r_{t} + \xi y_{t}^{F} e_{t} r_{t}^{F} \]  
(A24)

\[ e_{t}/e_{t-1} = S_{t} \pi_{t}^{*} / (S_{t-1} \pi_{t}) \]  
(A25)

\[ E_{t} \log S_{t+1} - \log S_{t} = \log R_{t} - \log R_{t}^{*} + p(D_{t}) \]  
(A26)

Equations (A1)–(A5) are the first-order conditions for households’ optimization problem. Equation (A6) describes the law of motion of capital.
Equation (A7) is the domestic goods market clearing condition. Defining the relative price of good \( z \), \( p_t(z)/P_t \), by \( r_p_t \), the next three equations express the demand functions faced by domestic firms. Equation (A11) gives the composition of domestic demand. The two equations following the production function given in Equation (A12) are the usual first-order conditions for firms’ optimization problem. We denote the optimal newly set relative price of good \( z \) that is sold in the domestic (foreign) market by a domestic PTM firm by \( \tilde{r}_p_t(\tilde{r}_p^F_t) \). Equations (A15) and (A16), thus, describe the pricing decisions of these firms, where we use the notation \( \pi_{t,s} = P_s/P_t \). In Equation (A17), the equation for the domestic price index, the variables \( r_p^SF_t \) and \( r_p^F_t \) denote the relative prices of foreign goods sold in the domestic country, that is \( r_p^SF_t = q_t(z^*)/P_t \) and \( r_p^F_t = p_t^*(z^*)/P_t^* \). Using the law of large numbers, Equations (A18) and (A19) describe optimal goods prices, i.e., the relative prices are a weighted average of past and optimal newly set relative prices. Equations (A20)–(A23) denote the law of motion for real balances, aggregate productivity, the growth rate of money, and risk premium shock. Equation (A24) is the budget constraint, and Equation (A25) is the definition of the real exchange rate. Equation (A26) is the linearized condition of uncovered interest rate parity. The condition of uncovered interest rate parity can be derived upon using the foreign budget constraint

\[
\frac{D^*_t}{S_t P^*_t} + \frac{F^*_t + M^*_t}{P^*_t} + C^*_t + I^*_t + \frac{\nu (N^*_t - N^*_t-1)^2}{2 N^*_t-1} + \frac{\psi (K^*_t - K^*_t)^2}{2 K^*_t} = R_{t-1} \frac{D^*_t-1}{S_t P^*_t} + \frac{R^*_t - 1}{P^*_t} F^*_t + M^*_t \]

and taking the first-order conditions with respect to \( D^*_t \) and \( F^*_t \) to get

\[
\lambda^*_t = \beta R_t S_t E_t \left[ \frac{\lambda^*_t+1}{\pi^*_t+1} \right] S_t \]

and

\[
\lambda^*_t = \beta R^*_t E_t \left[ \frac{\lambda^*_t}{\pi^*_t+1} \right] \]

Then combining the last first-order conditions, linearizing the result, and adding the risk premium, which consists of a stationarity inducing device and a risk premium shock as described in the main body of the text, gives Equation (A26).

Non-technical Summary

We lay out a dynamic stochastic general equilibrium two-country macroeconomic model featuring a labour-market friction to analyse how
financial market integration affects the propagation of monetary policy in an open economy. Our model captures the observation that international financial markets tend to quickly adjust to macroeconomic developments, whereas adjustment processes in the labour market are not costless and usually take time. In order to incorporate slow and costly adjustment processes in the labour market into an otherwise standard open-economy dynamic general equilibrium model, we consider a labour market friction that comes in the form of costs of adjusting hours worked. Costs of adjusting hours worked imply that optimizing households seek to smooth hours worked over time. Using numerical simulations of the calibrated model, we show that costs of adjusting hours worked improve, along various dimensions, the empirical fit of the model relative to the empirical fit of a model that assumes frictionless adjustment processes in the labour market. We measure the empirical fit of the model in terms of unconditional standard deviations and cross-country correlations of key macroeconomic variables. We then confirm results reported in earlier research by documenting that financial market integration leads to an increase in the effect of monetary policy on output and hours worked. Our results, however, also show that the magnitude of this increase crucially depends upon the structure of the labour market. We demonstrate that costs of adjusting hours worked substantially dampen the increase in the effect of monetary policy on output and hours worked brought about by financial market integration. We show that this key result is robust to various changes in the calibration and specification of our model. To this end, we vary the degrees of price flexibility, the country sizes, and the degree of goods market segmentation. We also report that costs of adjusting hours worked dampen the increase of the effect of monetary policy on output and hours worked in case of financial market integration irrespective of whether we measure monetary policy in terms of the growth rate of money supply or an interest rate rule.