Housework and fiscal expansions∗

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Abstract

We argue that explicitly modelling a home production sector as an alternative option to market work is crucial for understanding the propagation of exogenous changes in public spending to macroeconomic variables. In fact, the substitutability between market and home produced goods is an important driver of the labor supply response to government expenditure shocks and, as a consequence, is key to explain the magnitude of fiscal multipliers, as well as the behavior of private market consumption after a fiscal expansion. We build an otherwise standard New-Keynesian model that encompasses a home production sector and we use both micro- and macroeconomic evidence to validate our predictions. If the elasticity of substitution between home and market goods is chosen in line with the microeconomic estimates our model delivers impulse response functions to government expenditure shocks that match the VAR evidence.

JEL Codes: E24, E32, E52
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1 Introduction

The recent financial crisis demanded daring initiatives in order to boost aggregate economic activity. Since conventional monetary policy has been limited by the zero bound, increasing political interest has turned to fiscal policy as a possible remedy. While fiscal policy for some years has been downplayed, it faced a renaissance with high expectations as to what it can accomplish. In many countries there has been a vivid debate on the need for a fiscal stimulus, its magnitude, and its composition, and several countries have undertaken fiscal stimulus packages. Calls for expansionary fiscal policy have been issued by many, including the G20 summit and the EU Commission.

The renewed interest for fiscal policy begged the questions of what role government expenditure can play in boosting aggregate demand. In the traditional literature on the effects of fiscal policy, the conclusions on its efficacy typically depend on the identification restrictions used to extract fiscal shocks from the data\(^1\). However, Perotti (2008) and Caldara and Kamps (2008) reconcile the evidence and conclude that shocks to government spending generate demand effects that typically increase consumption and output. The estimated size of output multipliers varies in the (0.4, 1.5) interval, but many recent contributions\(^2\) argue that multipliers can be even larger during recessions, reconfirming the seminal intuition by Keynes.

On the theoretical side, standard theories of business cycles have a hard time to generate output multipliers that quantitatively match the estimates, because the negative wealth effect following a fiscal stimulus detains the expansion of aggregate economic activity. As emphasized by Hall (2009), two key features are needed for a model to deliver sizeable multipliers: a decline in price mark-ups occurring when production rises and a sufficiently elastic response of employment. The former mechanism couples the output expansion with a redistribution of profits from producers to households in the form of higher real wages that makes it particularly attractive to work and to consume when the government is spending. If labor supply is sufficiently elastic, the surge in employment is strong enough to generate a large output multiplier as well as an increase in consumption.

In this paper, following the argument by Hall (2009), we propose a model of housework and nominal rigidities where the substitutability between home-produced and market goods is an important driver of labor supply elasticity. Our model can account for the observed output multiplier, if the elasticity of

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\(^2\)In particular, recent empirical work incorporates the notion that fiscal policy might have non-linear effects depending on whether: the economy is in a recession or in an expansion (Auerbach and Gorodnichenko (2012)); unemployment rates are high or low (Barro and Redlick (2011)); the nominal interest rate has reached or not the zero lower bound (Christiano, Eichenbaum and Rebelo (2011), Erceg and Linde (2010) and Canova and Pappa (2011)).
substitution between home and market goods is calibrated in line with the available microeconomic evidence. Our emphasis on home production is motivated by recent theoretical and empirical contributions pointing to the great deal of substitutability between housework and market work. The American Time Use Survey confirms indeed that households spend between 11 and 18 percent of their time endowment in home related activities, producing services that are not exchanged on the market. Also, purchases of consumer durable goods and residential investment exceed purchases of producer durable goods and non-residential investment in the United States. Aguiar and Hurst (2005, 2007) document that over the life-cycle people substitute market work with housework. In fact, retirees rely on home production to compensate for the fall in the value of market purchases typically following the exit from the labor force. In the same vein, Aguiar, Hurst and Karabarbounis (2012) document substitutability between housework and market work over the business cycle, by estimating that home production absorbs about 30 percent of foregone market work. Benhabib, Rogerson and Wright (1991) and Greenwood and Hercowitz (1991) were the first to claim that home production is an empirically significant entity and its inclusion in an otherwise standard business cycle model is helpful to account for macroeconomic data. McGrattan, Rogerson and Wright (1997) first introduced housework in a real business cycle model with fiscal policy. Karabarbounis (2012) shows that a model with home production can account for cyclical fluctuations of the labor wedge. The novelty of our paper is to show that substitutability between market and non-market activity, coupled with a fall of price mark-ups, provides the key features advocated by Hall (2009) to reconcile the theory with the conditional evidence on fiscal expansions.

Our findings contribute to the literature in several respects. First, we present a channel for generating increases in private consumption and significant output effects after a government spending shock. In particular, we focus on how housework affects the dynamics in an otherwise standard New-Keynesian model and we determine the structural parameters that are crucial in matching the model with the empirical predictions. In line with previous theoretical contributions, price stickiness, and some, though small, capital adjustment costs are crucial for our channel to be operative. Under flexible prices, a positive government expenditure shock only generates, through a negative wealth effect, an increase of the labor supply and a consequent fall in the real wage. In other words, households do not work more because they find it more attractive, but simply because they want to partially smooth the reduction in consumption that is necessary to finance the increased tax burden. As a consequence, irrespective of the elasticity of substitution between home and market goods, labor supply is never elastic enough to boost market consumption and to match the observed size of the output multiplier. Similarly, without adjustment costs to capital, households smooth the shock by reducing investment, a fact that not only detains the increase of

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3On the role of nominal rigidities and non-separability between consumption and leisure see Woodford (2011), Hall (2009) and Basu and Kimball (2002).
aggregate demand, but that also depresses future labor market productivity and the real wage. Only when both of these features are present, one can make the labor supply elastic enough to generate an increase of market consumption by including in the model a home production sector. Also, the way monetary and fiscal policy interact is key. In line with the case made by Canova and Pappa (2011), Christiano et al. (2011) and Erceg and Linde (2010), if the monetary authority reacts too strongly to inflation, after a government expenditure shock the real interest rate increases so as to make consumption fall. Hence, in order to match the VAR evidence we include an interest rate smoother in the monetary policy rule that allows us both to reproduce the estimated muted response of the nominal interest rate and to generate a sizeable output multiplier.

Second, and more broadly, we see our result as pointing to the importance of modelling housework as an alternative option to market work, if one wants to rely on business cycle models to predict the effects of policy. In fact, the substitutability between home and market goods interacts with nominal and real frictions in driving households’ incentive to participate in the labor market. Since fiscal and monetary policies affect the relevance of frictions at business cycle frequencies, models neglecting the home sector may lead to incorrect conclusions about the evaluation of those policies. In our particular case, model abstracting from housework understate the elasticity of labor supply and this fact is partially responsible for the failure of baseline business cycle models to account for the VAR evidence on fiscal shocks.

Finally, our results are relevant for the literature suggesting consumption and hours’ complementarities in the utility function as a way of generating increases in consumption after a fiscal expansion. For instance, see Monacelli and Perotti (2008), Hall (2009), Christiano et al. (2011) and Nakamura and Steinsson (2011). The intuition behind their mechanism is simple: if consumption and hours worked are complements, the negative wealth effect originating from the increase in government’s absorption should result in a positive consumption response and, as a result, in a higher output multiplier. Our home production model with high substitutability between market and home consumption nests a reduced-form model without home production, but in which market consumption and market work are strong complements in the utility function. Yet, explicitly modelling housework offers the noticeable advantage of tying the importance of the transmission channel to the data by relying on the abundant microeconomic evidence.

Our goal is not to give a general theory of the effects of fiscal policy on macroeconomic variables, neither to offer an exhaustive explanation of the VAR evidence. Rather, we view our mechanism as complementary to the many alternative explanations suggested by the literature: Woodford (2011) considers that making consumption respond to current income, according to the old Keynesian tradition, generates sizeable demand effects and output multipliers; along this

\footnote{See Brückner and Pappa (2010) and Campolmi and Gnocchi (2011) for a similar argument applied to the effects of monetary and fiscal policy on unemployment.}
line, Galí, Lopez-Salido and Valles (2007) were the first to model rule-of-thumb consumers in order to break the link between the real interest rate and private consumption, allowing thus the latter to react to current income. Corsetti, Meier and Muller (2009) explain a positive private consumption response with spending reversals: current higher government expenditure implies permanently lower future expenditure, so as to keep constant long-run government debt. In their setup, an increase in government spending implies higher consumption both in the future and, through consumption smoothing, at the time of the shock. Finally, Morten, Schmitt-Grohé and Uribe (2012) focus on deep habits. In this case, an increase in domestic aggregate demand provides an incentive for firms to lower markups shifting the labor demand curve outwards and increasing real wages. The rise in wages induces households to substitute consumption for leisure and this substitution effect can be strong enough to offset the negative wealth effect and result in an equilibrium increase in private consumption.

The rest of the paper is organized as follows: Section 2 presents the model and Section 3 its baseline parametrization. Section 4 describes the dynamics of the model after a fiscal expansion, examines the sensitivity of the results to changes in key parameters and compares the model with the VAR evidence. Section 5 concludes.

2 The Model

We consider an otherwise standard New-Keynesian model, where households have access to a technology that combines time and capital to produce non-tradable home goods. As in Benhabib et al. (1991) and McGrattan et al. (1997)\(^5\), households enjoy leisure and consumption of a composite index that aggregates market and home goods according to a constant elasticity of substitution. The central bank is in charge of setting the nominal interest rate. The fiscal authority buys market goods and finances expenditures by levying a mix of lump-sum and distortive taxes. In what follows we define the economic environment and agents’ optimality conditions. We summarize the full system of equations defining the competitive equilibrium in Appendix A.

2.1 Policy makers

In the economy there are infinitely many varieties of final market consumption goods indexed by \(i \in [0, 1]\). The fiscal authority buys each market variety \(G_t(i)\) at its market price \(P_t(i)\). We define aggregate government expenditure, \(G_t\), as a composite index

\[
G_t = \left[ \int_0^1 (G_t(i))^{\frac{\varepsilon - 1}{\varepsilon}} \, di \right]^{\frac{\varepsilon}{\varepsilon - 1}} \quad \text{(2.1)}
\]

\(^5\)Differently from Greenwood and Hercowitz (1991) we allow households to substitute leisure with time spent working either at home or on the market.
where $\varepsilon > 1$ is the constant elasticity of substitution across varieties and $\log(G_t)$ exogenously evolves according to an AR(1) process, with mean equal to some parameter $\log(G)$. We assume that the government chooses the quantities $G_t(i)$ in order to minimize the total expenditure $\int_0^1 P_t(i) G_t(i)\, di$, given $G_t$. Hence, the condition
\[
G_t(i) = \left( \frac{P_t(i)}{P_t} \right)^{-\varepsilon} G_t
\] (2.2)
pins down public consumption of each variety $i$ where
\[
P_t = \left[ \int_0^1 P_t(i)^{1-\varepsilon} \, di \right]^\frac{1}{1-\varepsilon}
\] (2.3)
Government expenditure is financed by a mixture of distortive taxes on households’ capital and labor income as well as by lump-sum taxes. Tax rates on capital and labor income are exogenously given and constant, while lump-sum taxes can be used in a state-contingent way to balance the government budget constraint in every period. The central bank chooses the nominal interest rate by following a simple Taylor rule that targets inflation\[
(1 + R_t) = \beta^{-1} \Pi_t^\Phi
\] (2.4)
with $\Phi > 1$ and $\Pi_t \equiv (P_t/P_{t-1})$.

### 2.2 Households

Preferences over consumption $C_t$ and leisure $l_t$ are defined by
\[
E_0 \sum_{t=0}^{\infty} \beta^t \left[ \left( C_t^b (l_t)^{1-b} \right)^{1-\sigma} - 1 \right]
\] (2.5)
where $b \in (0, 1)$, $\sigma \geq 1$ and $C_t$ is an index that combines market and home goods denoted by $C_{m,t}$ and $C_{n,t}$, respectively, according to
\[
C_t = \left[ \alpha_1 (C_{m,t})^{b_1} + (1 - \alpha_1)(C_{n,t})^{b_1} \right]^{\frac{1}{b_1}}
\] (2.6)
$\alpha_1 \in [0, 1]$ and $b_1 < 1$. Therefore, households can substitute market and home goods at a constant elasticity\footnote{Recall the following limiting cases: when $b_1$ approaches one, $C_{m,t}$ and $C_{n,t}$ are perfect substitutes. They are instead perfect complements if $b_1$ tends to minus infinity. $b_1 = 0$ nests the Cobb-Douglas specification.} $1 - b_1)^{-1}$. The market good is the standard Dixit-Stiglitz aggregator of the infinitely many varieties of market consumption goods
\[
C_{m,t} = \left[ \int_0^1 (C_{m,t}(i))^\frac{-1}{b_1} \, di \right]^\frac{b_1}{-1}
\] (2.7)
and can be bought for either consumption or investment purposes. Aggregate investment also combines varieties as in (2.7), at the same elasticity of substitution $\varepsilon$. Let investment be denoted by $I_t$. Hence, capital evolves over time according to

$$K_{t+1} = (1 - \delta)K_t + \exp\{\mu_t\}I_t - \frac{\xi}{2}\left(\frac{K_{t+1}}{K_t} - 1\right)^2$$  \hspace{1cm} (2.8)

and it depreciates at a rate $\delta$. We allow for positive capital adjustment costs by setting $\xi > 0$ and we consider an investment specific shock $\mu_t$. In each period, the existing capital stock can be rented to firms or used by the household for home production. Let $K_{m,t}$ be the capital stock available to firms and $K_{n,t}$ the capital stock available for non-market activity. Hence,

$$K_t = K_{m,t} + K_{n,t}$$  \hspace{1cm} (2.9)

Home goods are not traded. Rather, the household produces them by allocating capital and labor to the following technology

$$C_{n,t} = \left[\alpha_2(K_{n,t})^{b_2} + (1 - \alpha_2)(\exp\{s_{n,t}\}h_{n,t})^{b_2}\right]^{\frac{1}{b_2}}$$  \hspace{1cm} (2.10)

where $h_{n,t}$ stands for hours worked at home, $s_{n,t}$ captures exogenous technological progress in the home production sector, $\alpha_2 \in [0, 1]$ and $b_2 < 1$. As an alternative to housework, time can be rented to firms so that the following constraint must hold

$$l_t = 1 - h_{m,t} - h_{n,t}$$  \hspace{1cm} (2.11)

where $h_{m,t}$ represents hours worked in the market and the time endowment is normalized to one. We assume that households are price-takers in all markets and that financial markets are complete. Therefore, optimal allocation of expenditure across varieties implies a flow budget constraint

$$E_t\{Q_{t+1}B_{t+1}\} + P_tC_{m,t} + I_t$$

$$\leq B_t + (1 - \tau_h)W_tP_th_{m,t} + (1 - \tau_k)r_tP_tK_{m,t} + \delta\tau_kP_tK_{m,t} + T_t$$  \hspace{1cm} (2.12)

$P_t$ is the minimum cost of a unit of the composite bundle $C_{m,t}$, as in (2.3), $B_{t+1}$ is a portfolio of state contingent assets and $Q_{t,t+1}$ is the stochastic discount factor for one-period ahead nominal payoffs. $r_t$ is the real rental price of market capital, $W_t$ is the real wage and the term $\delta\tau_kP_tK_{m,t}$ arises because we assume that depreciated market capital is tax deductible. Finally, $T_t$ includes all lump-sum transfers and taxes, in addition to the profits stemming from market power.

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7The stochastic discount factor in period $t$ is the price of a bond that delivers one unit of currency if a given state of the world realizes in period $t + 1$, divided by the conditional probability that the state of the world occurs given the information available in $t$. The nominal interest rate $R_t$ relates to the discount factor according to $(1 + R_t) = \{E_tQ_{t,t+1}\}^{-1}$ by a standard no-arbitrage argument.
Given initial values of the capital stock \( K_0 \) and assets \( B_0 \), and given all prices and policies, households choose state-contingent sequences of: aggregate, market and home consumption, \( C_t, C_{m,t} \) and \( C_{n,t} \), respectively; leisure, \( l_t \), and hours worked both on the market, \( h_{m,t} \), and at home, \( h_{n,t} \); the stock of capital rented to firms, \( K_{m,t} \), and the stock used in the non-market production, \( K_{n,t} \); investment, \( I_t \), as well as the total capital stock, \( K_{t+1} \), and the amount of bonds \( B_{t+1} \) to carry over to the next period. The solution to the households’ problem needs to satisfy three intra-temporal conditions

\[
\alpha_1 \frac{C_{m,t}}{C_{n,t}}^{b_1 - 1} = \frac{1 - \alpha_2}{W_t(1 - \tau_h)} \frac{C_{n,t}}{h_{n,t}}^{1 - b_2} [\exp\{s_{n,t}\}]^{b_2} \quad (2.13)
\]

\[
\alpha_1 \frac{C_{m,t}}{C_{n,t}}^{b_1 - 1} = \frac{\alpha_2}{(1 - \tau_k)r_t + \delta \tau_k} \frac{C_{n,t}}{K_{n,t}}^{1 - b_2} \quad (2.14)
\]

\[
W_t(1 - \tau_h)(1 - h_{n,t} - h_{m,t}) = \frac{1 - b}{b\alpha_1} \frac{C_{m,t}^{1 - b_1}}{C_t^{b_1}} \quad (2.15)
\]

Equation (2.13) drives the optimal allocation of time between the home and the market sector. It establishes that the marginal rate of substitution between home and market consumption has to equalize the corresponding relative price which is the ratio between the return to housework, i.e. the marginal productivity of labor in the non-market sector, and the return to market work, i.e. the after-tax real wage. Similarly, equation (2.14) requires that the marginal rate of substitution between the two consumption goods is equal to the ratio of returns to capital in the two sector, marginal productivity of capital at home and the after-tax market rental rate of capital, taking into account that depreciation is tax deductible. Obviously, taken together, the two conditions imply that returns to labor, relative to capital, are equalized across sectors which is a direct consequence of the fact that the household can freely re-allocate both time and capital between market and non-market activity. Equation (2.15) is the standard intra-temporal optimality condition solving for the leisure-consumption trade-off.

In addition, two conventional Euler equations are required for the allocation to be optimal inter-temporally, one for the capital stock and one for financial assets

\[
\beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \frac{\exp\{\mu_t\}}{\exp\{\mu_{t+1}\}} \left[ 1 + \frac{\xi}{K_t} \left( \frac{K_{t+1}}{K_t} - 1 \right) \right]^{-1} \right\} = 1 \quad (2.16)
\]

\[
\beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} (1 + R_t) \Pi_{t+1}^{-1} \right\} = 1 \quad (2.17)
\]

where \( \lambda \) denotes the marginal utility of consumption and reads as

\[
\lambda_t = b\alpha_1 (1 - h_{n,t} - h_{m,t})^{(1-b)(1-\sigma)}C_{m,t}^{b_1 - 1} (C_t)^{b(1-\sigma) - b_1} \quad (2.18)
\]
2.3 Firms

Each market good variety \( i \) is produced by a monopolistically competitive firm that combines market capital and time according to the production function

\[
Y_t(i) = \left[ \alpha_3(K_{m,t}(i))^{b_3} + (1 - \alpha_3)(exp{s_{m,t}})h_{m,t}(i) \right]^{\frac{1}{b_3}} \tag{2.19}
\]

where \( \alpha_3 \in [0,1] \), \( b_3 < 1 \) and \( s_{m,t} \) represents labor augmenting technological progress. Cost minimization with respect to capital and labor subject to the technological constraint (2.19) yields

\[
\alpha_3 RMC_t \left( \frac{K_{m,t}(i)}{Y_t(i)} \right)^{b_3-1} = r_t \tag{2.20}
\]

\[
(1 - \alpha_3) RMC_t \left( \frac{h_{m,t}(i)}{Y_t(i)} \right)^{b_3-1} [exp{s_{m,t}}]^{b_3} = W_t \tag{2.21}
\]

where \( RMC_t \) is the real marginal cost which is constant across all firms \( i \) as an implication of constant returns to scale and perfect competition on the markets of all factors of production. We follow Calvo (1983) and we assume that in any given period each firm resets its price \( P_t(i) \) with a constant probability \( (1 - \theta) \).

The demand of any good \( i \) is

\[
Y_t(i) = \left[ \frac{P_t(i)}{P_t} \right]^{-\frac{\varepsilon}{\varepsilon-1}} Y_t^d \tag{2.22}
\]

where \( Y_t^d \equiv [C_{m,t} + I_t + G_t] \). Maximization of profits

\[
E_t \left\{ \sum_{j=0}^{\infty} \theta^j Q_{t,t+j} [P_t(i)Y_{t+j}(i) - P_{t+j}RMC_{t+j}Y_{t+j}(i)] \right\} \tag{2.23}
\]

subject to constraint (2.22) yields the following first order condition for any firm \( i \) that is allowed to re-optimize in period \( t \)

\[
E_t \left\{ \sum_{j=0}^{\infty} \theta^j Q_{t,t+j} Y_{t+j}(i) \left[ \frac{P_t^*}{P_t} - \frac{\varepsilon}{\varepsilon-1} RMC_{t+j} \Pi_{t,t+j} \right] \right\} = 0 \tag{2.24}
\]

\( P_t^* \) is the optimal price, \( Q_{t,t+j} \) denotes the stochastic discount factor in period \( t \) for nominal profits \( j \) periods ahead and it is such that

\[
Q_{t,t+j} = \beta^j E_t \left\{ \frac{\lambda_{t+j}}{\lambda_t} \Pi_{t,t+j}^{-1} \right\} \tag{2.25}
\]

and \( \Pi_{t,t+j} \equiv (P_{t+j}/P_t) \). Calvo-pricing conventionally implies the following relation between inflation and the relative price charged by re-optimizing firms.
\[ \frac{P^*_t}{P_t} = \left( \frac{1 - \theta \Pi^\varepsilon_t^{-1}}{1 - \theta} \right)^{\frac{1}{1 - \varepsilon}} \]  

(2.26)

The necessary condition for profit maximization (2.24) can easily be rewritten as

\[ \frac{P^*_t}{P_t} = \frac{x_{1,t}}{x_{2,t}} \]  

(2.27)

where the auxiliary variables \( x_{1,t} \) and \( x_{2,t} \) are recursively defined by

\[ x_{1,t} = Y_t^d \frac{\varepsilon}{\varepsilon - 1} RMC_t + \beta \theta E_t \left\{ \frac{\lambda_{t+1} \Pi^\varepsilon t_{t+1} x_{1,t+1}}{\lambda_t} \right\} \]  

(2.28)

\[ x_{2,t} = Y_t^d + \beta \theta E_t \left\{ \frac{\lambda_{t+1} \Pi^\varepsilon t_{t+1} x_{2,t+1}}{\lambda_t} \right\} \]  

(2.29)

### 2.4 Aggregation and market clearing

After defining aggregate production \( Y_t \)

\[ Y_t = \left[ \frac{1}{0} (Y_t(i))^{\varepsilon - 1} di \right]^{\frac{\varepsilon}{\varepsilon - 1}} \]  

(2.30)

the clearing of all final goods markets implies

\[ Y_t = C_{m,t} + I_t + G_t \]  

(2.31)

Define the market capital-labor ratio, \( k_t \equiv (K_{m,t}(i)) / (h_{m,t}(i)) \). By equations (2.20) and (2.21) the ratio is constant across firms and satisfies

\[ k_t = \left[ \frac{r_t(1 - \alpha_3) exp\{s_{m,t}\}}{W_t \alpha_3} \right]^{\frac{1}{b_3 - 1}} \]  

(2.32)

Let aggregate labor demand \( h_{m,t}^d \) be

\[ h_{m,t}^d = \int_0^1 h_{m,t}(i) di \]  

(2.33)

that coincides with \( h_{m,t} \) by the clearing of the labor market. Therefore, integrating equation (2.19) over all firms \( i \) yields

\[ Y_t = \Delta_t^{-1} \left[ \alpha_3 k_t^{b_3} + (1 - \alpha_3) \right]^{\frac{1}{b_3 - 1}} h_{m,t} \]  

(2.34)

where \( \Delta_t \) denotes relative price dispersion which reads as

\[ \Delta_t = \int_0^1 \left( \frac{P_t(i)}{P_t} \right)^{-\varepsilon} di \]  

(2.35)

and it is a state-variable that evolves according to
\[ \Delta_t = (1 - \theta) \left( \frac{P^n_t}{P^*_t} \right)^{-\varepsilon} + \theta \Pi_t^\varepsilon \Delta_{t-1} \]  

(2.36)

It is well-known that \( \log(\Delta_t) \) is a second order term and can thus be neglected when the model is approximated to the first order around the non-stochastic steady state. Aggregate demand of market capital is

\[ K_{d,m,t} = \int_0^1 K_{m,t}(i) \, di \]  

(2.37)

It follows that the clearing of the capital rental market implies the relation

\[ K_{m,t} = k h_{m,t} \]  

(2.38)

Finally, by using (2.38) into (2.34), one can obtain the aggregate production function

\[ Y_t = \Delta_t^{-1} \left[ \alpha_3 K_{m,t}^{b_3} + (1 - \alpha_3) h_{m,t}^{b_3} \right]^{\frac{1}{b_3}} \]  

(2.39)

as well as the aggregate counterparts of equations (2.20) and (2.21)

\[ \alpha_3 RMC_t \left( \frac{K_{m,t}}{\Delta Y_t} \right)^{b_3-1} = r_t \]  

(2.40)

\[ (1 - \alpha_3) RMC_t \left( \frac{h_{m,t}}{\Delta Y_t} \right)^{b_3-1} \left[ \exp\{s_{m,t}\} \right]^{b_3} = W_t \]  

(2.41)

### 3 Parametrization of the model

To begin with, we restrict the elasticity of substitution in production to 1 by choosing \( b_2 \) and \( b_3 \) equal to 0. We do so in order to be comparable with most of the related literature that focuses on the case of Cobb-Douglas production functions\(^8\).

We resort to data in order to calibrate as many structural parameters as we can, so as to match the value of endogenous variables at the non-stochastic steady state with their observable counterparts. By doing so, we determine the following parameters: \( \alpha_1, \alpha_2, \alpha_3, G, \delta \) and \( b \). Ten structural parameters are left to be determined: the discount factor \( \beta \); tax rates \( \tau_k \) and \( \tau_h \); the elasticity of substitution between market and home goods \((1 - b_1)^{-1}\); price stickiness \( \theta \); the elasticity of substitution across market good varieties, \( \varepsilon \); the inverse of the inter-temporal elasticity of substitution, \( \sigma \); capital adjustment costs \( \xi \); the Taylor rule coefficient \( \Phi_\pi \). These parameters can hardly be identified by matching the steady state with the data and they are potentially crucial for the dynamic response of endogenous variables to shocks. Hence, we discipline the model by using information coming from previous studies. In the next section, we

\(^8\)Table 1 summarizes the values for the other parameters.
perform extensive sensitivity analysis with respect to all of them in order to make clear how the parametrization affects our results. We set the discount factor $\beta$ to 0.99 which implies an annual interest rate of roughly 4 percent per year. In the baseline parametrization, we restrict to the case of lump-sum taxation, as in most of the literature that investigates the ability of standard business cycle models in replicating empirical impulse responses of market consumption to government expenditure shocks. We choose $\theta = 0.75$, $\varepsilon = 11$, $\sigma = 2$, and $\Phi_\pi = 1.5$, a calibration that is fairly standard in business cycle models. As far as capital adjustment costs are concerned, estimates display great variability, ranging from $\xi = 3$ to $\xi = 110$. We restrict to a value in the middle range, $\xi = 50$. $(1 - b_1)^{-1}$ is the parameter we are mostly interested in since affects significantly the elasticity of labor supply to $G$ shocks. To have a broad idea of an empirically relevant range for $(1 - b_1)^{-1}$, one can refer to a variety of both micro- and macroeconomic studies that find estimates between 1.8 and 5. We fix the elasticity to 4, implying $b_1 = 0.75$. However, in most of our exercises we leave the parameter free to vary, so as to assess its importance for the sensitivity of our results.

### 3.1 Data

We collect time series of capital, investment, market consumption, government expenditure and the consumer price index (price index for personal consumption expenditure) from the U.S. Bureau of Economic Analysis. All the series refer to the time period 1950:Q1-2007:Q2, excluding the financial crisis, they are available at a quarterly frequency, with the exception of capital that is annual, and they are all seasonally adjusted. The data have been downloaded in current dollars and divided by the consumer price index. We obtain a measure of GDP by summing up market consumption, investment and government expenditure. We only consider purchases of goods in government expenditure and we exclude purchases of non-military durable goods and structures. The series of market consumption includes non-durable goods and services, after subtracting the value of services from housing and utilities that in turn we consider as a part of the non-market sector. We obtain total investment by adding purchases of durable goods to the fixed investment component, both residential and non-residential, but we leave out inventories, as in Smets and Wouters (2007). Consistently, we

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9For a survey see Neiss and Pappa (2002)
10The preferred calibration chosen by Benhabib et al. (1991) in their seminal contribution about home production is 5. McGrattan et al. (1997) estimate a version of the model by Benhabib et al. (1991) via maximum likelihood and find a value slightly below 2. Chang and Schorfheide (2003) estimate a home production model with Bayesian techniques and find that $(1 - b_1)^{-1}$ is roughly 2.3. Aguiar et al. (2012) use data from the American Time Use Survey (ATUS) to establish that home production absorbs about 30 percent of foregone market work hours at business cycle frequencies. Then, they show that the Benhabib et al. (1991) model is consistent with the ATUS evidence under a 2.5 elasticity. Karabarbounis (2012) shows that a value of 4 accounts for cyclical fluctuations of the labor wedge.
11This is conventional in the home production literature. See for instance McGrattan et al. (1997).
assign fixed non-residential assets to market capital, while we consider residential assets and the stock of durable goods as part of the home capital. Government expenditure as a share of GDP amounts to 0.18, which we use to calibrate the mean of the stochastic process for public spending $G$. The market and home capital to output ratio, 1.29 and 1.69, are informative for choosing technology parameters $\alpha_3$ and $\alpha_2$, respectively. Data on capital and investment pin down the depreciation rate $\delta$. We normalize the time endowment to 1 and we match steady state hours worked in the market and in the home sector with averages observed in the data by choosing utility parameters $b$ and $\alpha_1$, respectively. To this purpose, we use the information contained in the American Time Use Survey (ATUS) as summarized by Aguiar et al. (2012). The ATUS provides nationally representative estimates of how Americans spend their time supplying data on a wide range of non-market activities, from child-care to volunteering, for a cross-section of roughly 100000 individuals over the period 2003-2010. Respondents are randomly selected from a subset of households that have completed their eight and final month of interviews for the Current Population Survey (CPS). As a fraction of the weekly endowment, time allocated to market work is 0.33, time for housework amounts to 0.19 and the rest is devoted to leisure which excludes sleeping, eating and personal care time.

### 3.2 Non-stochastic steady state and calibration

We find the non-stochastic steady state of the model by setting all shocks to their unconditional mean which we normalize to 0 for $s_m$, $s_n$ and $\mu$. Then, the equilibrium conditions evaluated at the non-stochastic steady state are used to recover the values of $\alpha_1$, $\alpha_2$, $\alpha_3$, $G$, $\delta$ and $b$, given the calibration targets. The steady state version of the capital accumulation equation, (2.8), determines the depreciation rate, $\delta$, by using data on capital and investment. The Euler equation on capital, (2.16), thus implies that the steady state rental rate is

$$r = \frac{1 - \beta \delta \tau_k - \beta (1 - \delta)}{\beta (1 - \tau_k)}$$

which is pinned down by knowing $\beta$, $\delta$ and the capital income tax rate. Equations (2.26)-(2.29), together with the monetary rule (2.4), imply that the steady state value of the real marginal cost is

$$RMC = \frac{\varepsilon - 1}{\varepsilon}$$

---

12 As reported by Aguiar et al. (2012) in Table B1 of their online Appendix, the average respondent devotes 31.62 hours to market work and 18.12 hours to home production per week. Our figures obtain after subtracting from the weekly time endowment sleeping, personal care and eating, for a total of 72.92 hours. Instead, if those activities are included, market work and home production time result in 0.18 and 0.11, respectively. Both ways of accounting time are used in the home production literature. We choose the former in our baseline calibration, but we check that our results are robust to the latter definition.

13 Instead, $\log(G)$ is chosen consistently with the data as we show below.
while \( \Pi = P^* / P = \Delta = 1 \) and \( 1 + R = \beta^{-1} \). By equation (2.40),

\[
\frac{K_m}{Y} = \left( \frac{r\varepsilon}{\alpha_3(\varepsilon - 1)} \right)^{\frac{1}{\alpha_3 - 1}} 
\tag{3.3}
\]

which allows to retrieve \( \alpha_3 \) given the market capital-to-output ratio, \( b_3 \) and \( \varepsilon \), after substituting equation (3.1). Furthermore, we use the production function (2.39) to find

\[
\frac{h_m}{Y} = \left[ \frac{1}{1 - \alpha_3} - \frac{\alpha_3}{1 - \alpha_3} \left( \frac{K_m}{Y} \right)^{b_3} \right]^{\frac{1}{b_3}} 
\tag{3.4}
\]

which is solely a function of known parameters. Therefore, given the target on \( h_m \), one can easily solve for \( Y \) and \( K_m \) via (3.3) and (3.4), while equation (2.41) determines the real wage \( W \)

\[
W = \frac{(1 - \alpha_3)(\varepsilon - 1)}{\varepsilon} \left( \frac{h_m}{Y} \right)^{b_3 - 1} 
\tag{3.5}
\]

If \( Y \) is known, it follows from definitions (2.28) and (2.29) that

\[
x_1 = x_2 = (1 - \beta \theta)Y 
\tag{3.6}
\]

Conditions (2.13) and (2.14) imply

\[
\frac{h_n}{Y} = \left[ \frac{\alpha_2 W(1 - \tau_h)}{(1 - \alpha_2)[(1 - \tau_k)r + \delta \tau_k]} \right]^{\frac{1}{\alpha_2 - 1}} \frac{K_n}{Y} 
\tag{3.7}
\]

and \( \alpha_2 \) must be chosen to make consistent the target on hours worked at home with the observed home capital-to-output ratio. Once \( \alpha_2 \) has been set, also \( K_n \) is pinned down, hence \( C_n \) can be found by using (2.10). Define \( g \) as the share of government expenditure in GDP. The resource constraint (2.31) together with (2.13) yields

\[
\frac{\alpha_1}{1 - \alpha_1} \left[ \frac{(1 - g)Y - I}{C_{n,t}} \right]^{b_1 - 1} = \frac{1 - \alpha_2}{W_t(1 - \tau_h)} \left[ \frac{C_{n,t}}{h_{n,t}} \right]^{1 - b_2} 
\tag{3.8}
\]

where all endogenous variables have been determined. As a consequence, given \( b_1 \) and \( b_2 \), \( \alpha_1 \) must be chosen such that (3.8) holds. Finally, \( G = gY \) while the labor supply equation (2.15) recovers the value of \( b \) consistent with all our targets.

4 Housework, market consumption and fiscal multipliers

The purpose of this section is twofold. First, we document that in the model substitutability between market and home consumption is an important driver
of the labor supply response to government expenditure shocks and, as a consequence, it affects the predicted magnitude of the fiscal multiplier as well as the effect on market consumption of fiscal expansions. Finally, we compare the predictions of our model with the VAR evidence on the macroeconomic consequences of exogenous changes in public spending.

4.1 Inspecting the mechanism

Under our calibration, market consumption increases after a positive government expenditure shock. This result stands in contrast with the predictions of a baseline business cycle model with nominal rigidities. Figure 1 makes clear the contribution of home production by comparing impulse response functions across two alternative parameterizations. We label as “GHP” the responses obtained under the calibration reported in Table 1, while “Baseline” refers to a counterfactual world where hours worked and capital in the home sector are set to zero. In both cases, we consider an exogenous increase in government expenditure that is normalized to one percentage point of steady state GDP and we analyze its impact on market consumption, hours worked on the market, real wages, GDP and investment. We assume\(^ {14}\) that the shock follows an \(AR(1)\) process with persistence \(\rho_g = 0.8\). The responses of consumption and investment have been expressed as shares of GDP, while for GDP and real wages we present percentage deviations from the steady state\(^ {15}\). As a consequence, the impact of the shock on GDP can be conventionally interpreted as the fiscal multiplier and directly compared to the corresponding VAR evidence. We maintain this normalization in the rest of the paper. It is evident that the “GHP” model implies bigger fiscal multipliers, as compared to the baseline, and it predicts a positive rather than negative consumption response. This is because the substitutability between the two goods induces a higher elasticity of labor supply to exogenous changes in public spending. The intuition of the result is straightforward. The household needs to pay for the shock out of her wealth in the form of higher current or future taxes, so that a temporary fiscal expansion has a negative wealth effect. Therefore, it is optimal to reduce investment on the one hand and to work more on the other hand, so as to spread the tax burden between lower savings and larger labor income. Also, in a model with nominal rigidities a positive government expenditure shock induces substitution of leisure and housework with market work for an additional reason. The fiscal expansion stimulates aggregate demand, reduces price mark-ups and consequently raises the real wage, making it relatively more attractive to work in the market sector. The wealth and the aggregate demand effects reinforce each other in boosting employment, but they push the real wage in opposite directions and the final outcome is ultimately

\(^{14}\)Monacelli and Perotti (2008, 2010) show that \(\rho_g = 0.8\), implying that roughly fifty percent of the shock dies out in about four quarters, is in line with the VAR evidence. We further discuss such value below when we compare our model with an identified government expenditure shock.

\(^{15}\)To this purpose, we multiply the log response of consumption and investment by their steady state shares in GDP. Everything is multiplied by 100 so that the scale is already in percentage points.
a quantitative question. In a model without home production market hours worked increase and generate a positive fiscal multiplier on output which is not large enough to allow for an increase of market consumption: the additional labor income is indeed only used to finance the tax burden. However, when the household has the possibility of reallocating time from housework to market activity, the incentive to do so clearly depends on the elasticity of substitution between home and market goods and one would expect a stronger response of hours when $b_1$ grows larger$^{16}$. Figure 2 confirms that this is indeed the case. In fact, if we reduce the elasticity of substitution from 4 to 1 and keep all the remaining parameters at the values displayed in Table 1, the response of hours is dampened enough to make market consumption fall, as in the baseline business cycle model. Not surprisingly, also the fiscal multiplier is smaller. Hence, we conclude that neglecting the substitutability between housework and market work downplays the actual elasticity of labor supply to fiscal shocks and, as a consequence, their impact on production and market consumption.

Nominal rigidities are key in shaping the relationship between the elasticity of substitution $b_1$ and the elasticity of labor supply to $G$ shocks, as it becomes clear from Figure 3, where the elasticity of substitution is kept constant and equal to its baseline value, while price stickiness varies from 0 to 0.75. If nominal rigidities are low enough, our transmission channel does not seem to be operative. This fact can be easily explained by the behavior of the real wage. When prices become more flexible, a fiscal expansion affects price mark-ups to a lesser extent. As a result, the outward shift of the labor supply curve due to the negative wealth effect becomes more and more important, relatively to the fall in mark-ups, and the real wage does not increase much or it even falls. It follows that a high elasticity of substitution between home and market goods cannot reinforce the increase in market hours worked: the household does not find it more attractive to work on the market, rather it works the amount needed to pay the tax burden and optimally smooth the shock over time. To conclude, the elasticity of substitution between home and market goods is relevant if households work more on the market after the shock not simply because they have to, but because they find it more attractive than home producing.

### 4.2 Robustness

We now discuss the robustness of our results. In fact, the model parametrization may hide some forces that can under- or overstate the quantitative importance of substitutability between market and home goods. We postpone to the next section an extended discussion emphasizing that a proper modelling of the interaction between monetary and fiscal policy is crucial to obtain sensible predictions$^{17}$. Two structural parameters are naturally expected to be relevant: the cost of ad-

$^{16}$Recall that higher values of $b_1$ imply a higher elasticity of substitution and when $b_1 = 0$ preferences are Cobb-Douglas.

$^{17}$For an illustration of the empirical importance of monetary accommodation after fiscal shocks see for instance Canova and Pappa (2011).
justment of the capital stock, \( \xi \), and the inverse of the inter-temporal elasticity of substitution, \( \sigma \). Intuitively, the former discourages households from smoothing the fiscal shock by reducing savings and investment. The latter, as emphasized by Basu and Kimball (2002), also acts through the inter-temporal margin and it affects the complementarity between hours worked and consumption. In particular, a smaller inter-temporal elasticity of substitution, i.e. a higher \( \sigma \), magnifies the relevance of our channel. We finally show that our results are robust to the inclusion of distortive tax rates on capital and labor income. In all of the following exercises we maintain parameters to the calibrated values displayed in Table 1, unless otherwise specified.

In Figure 4, we plot the impulse response function of market consumption for different values of \( \xi \) that we decrease from 50 to the lower bound of the empirically relevant range, 3. This exercise shows that capital adjustment costs are important for the elasticity of labor supply to government expenditure shocks. However, under our baseline parametrization, market consumption increases for all the values of the adjustment cost that are above the lower bound typically used in the literature.

As far as \( \sigma \) is concerned, its quantitative relevance is assessed in Figure 5. The left hand panel displays the impulse response of market consumption for different values of \( \sigma \), while the right hand panel shows the corresponding plots for the model without a home production sector. It is evident that the inter-temporal elasticity of substitution is a key parameter, even though an elasticity in line with the microeconomic evidence cannot generate a rise in market consumption if a home production sector is not included in the model.

Figure 6 makes sure that the inclusion of distortive tax rates on capital and labor income does not undermine our results. In particular, the figure plots the impulse response of market consumption and GDP when capital and labor are taxed at rates equal to 0.57 and 0.23, respectively. The values have been chosen in line with the estimates by McGrattan et al. (1997).

We conclude this section by showing that under a plausible parametrization the model is not able to generate a positive response of market consumption either when the home production sector is not included or when one abstracts from nominal price rigidities. To this purpose, we consider 50000 draws of parameters from uniform distributions defined over an empirically relevant range. In particular, we consider the following parameters with their respective bounds: \( \theta \in [0, 0.8] \), \( \xi \in [0, 0.25] \), \( \rho_g \in [0, 0.99] \), \( \Phi_\pi \in [1.1, 1.5] \), \( \epsilon \in [6, 11] \), \( G \in [0.05, 0.25] \), and \( b_1 \in [0.3, 0.8] \). The 50000 draws generate a distribution of impulse response functions of market consumption to government expenditure shocks. Figure 7 plots the median, the 75-th and the 25-th quantiles of such distribution. The left hand panel reports the case without home production but with nominal rigidities, while the right hand panel shows the case of home production under flexible prices.
4.3 Comparison with the VAR evidence

The VAR evidence seems to agree that fiscal expansions stimulate demand and increase aggregate consumption. See for instance Caldara and Kamps (2008) and Perotti (2008). Various theories accounting for the VAR estimates have been proposed in the literature. Our main argument is not meant to be an exhaustive alternative explanation, rather it is intended to point out that the substitutability between market and home consumption has important effects on the labor supply elasticity that are relevant for fiscal expansions. Still, we believe it is interesting to see to what extent our channel alone is consistent with the conditional evidence. To this purpose, we identify fiscal shocks by resorting to the restriction proposed by Blanchard and Perotti (2002) and we quantify their impact on market consumption, GDP and the nominal interest rate in the data. Then, we compare the empirical responses with the predictions of our model. We are interested in the behavior of the nominal interest rate, because, as we anticipated above, modelling the interaction between monetary and fiscal policy is crucial.

In addition to the data described above, we collect the quarterly and seasonally adjusted time series of tax revenues net of transfers from the U.S. Bureau of Economic Analysis and the three month treasury bill rate from the Federal Reserve Bank of St. Louis database. The reduced form model contains a constant and a trend and the following variables in this particular order: The log of real per capita tax revenues, the log of real per capita government consumption expenditures, the log of real GDP per capita, the log of real private consumption expenditures and the rate on T-bills. The lag length of our VAR model is based on information criteria and set equal to two. The ordering of the variables in the VAR implies that government spending does not react contemporaneously to changes in output and private consumption, nor to changes in the monetary policy instrument\footnote{We have used alternative sign restrictions to identify the government spending shock as a shock that moves positively output, deficits and government spending. Results are very similar and we do not present them here for economy of space.}. Figure 8 presents the responses of endogenous variables to a shock in government spending normalized to one percent of GDP. After the shock, both output and consumption increase significantly and tax revenues react positively with a lag. The nominal interest rate does not react significantly on impact, it increases two periods after the shock and falls thereafter and significantly so approximately six quarters after the initial impact.

In order to compare the model to the data, we perform the following exercise. First, we choose a monetary policy rule that qualitatively matches the response of the nominal interest rate to an expansionary fiscal shock. Then, we look for the elasticity of substitution between home and market goods such that the model delivers an impact response of market consumption that is consistent with the data. Finally, we make sure that the needed value of $b_1$ agrees with previous estimates and, in particular, with microeconomic data.

A simple Taylor rule as the one assumed in (2.4) implies that the central bank...
tightens the monetary stance by raising the nominal interest rate, after an expansionary fiscal shock. However, even though the monetary policy maker wants to aggressively react to inflation unconditionally, she may prefer to accommodate an exogenous government expenditure shock and avoid increasing the interest rate right when the fiscal policy maker is expanding. This intuition seems to be consistent with our estimated response of the nominal interest. A simple monetary rule augmented with an interest rate smoother that keeps a long-run inflation response of 1.5 as in (2.4) qualitatively replicates the conditional evidence. Hence, we consider the following rule

\[(1 + R_t) = (1 + R_{t-1})^{\rho_m} \left\{ \beta^{-1} \Pi_{t}^{\Phi_{\pi}} \right\}^{1-\rho_m} \] (4.1)

We maintain $\Phi_{\pi}$ as in Table 1 and we choose $\rho_m = 0.82$. Also, we set $\rho_g = 0.85$ to match the persistence of the identified government expenditure shock. Finally, we choose $b_1 = 0.8$. Figure 8 shows that our mechanism is able to reproduce the conditional evidence on the response of market of consumption and it generates a fiscal multiplier higher than 1, that is however somewhat over-predicted. Since $b_1 = 0.8$ is admittedly on the upper bound of available estimates, we repeat the comparison in Figure 9 by imposing a more conservative parametrization and setting $b_1 = 0.6$. In this case, we can explain about half of the response of consumption and we match exactly the impact response of GDP. The model fails to replicate the persistence of both consumption and output.

5 Conclusions

We build an otherwise standard New-Keynesian model that encompasses a home production sector and we show that, for plausible calibrations of the elasticity of substitution between home and market goods, after a fiscal expansion market consumption increases. In addition, we can match the predicted size of the output multipliers with the empirical estimates. The presence of nominal rigidities and the possibility of substituting housework with market work makes it more attractive to work on the market and to consume market goods when the government is spending. The higher elasticity of labor supply to government expenditure shocks explains the improved ability of the model to match the conditional evidence, as compared to the baseline business cycle model.

References


A Equilibrium Definition

The equilibrium of the model is a set of state contingent plans for variables $C_t$, $C_{m,t}$, $C_{n,t}$, $K_{m,t}$, $K_{n,t}$, $K_t$, $h_{m,t}$, $h_{n,t}$, $I_t$, $\lambda_t$, $Y_t$, $\Pi_t$, $\Delta_t$, $I_t^b$, $x_{1,t}$, $x_{2,t}$, $RMC_t$, $R_t$, $W_t$ and $r_t$ that satisfy the following system of equations:

\[
C_t = \left[ \alpha_1(C_{m,t})^{b_1} + (1 - \alpha_1)(C_{n,t})^{b_1} \right]^{\frac{1}{b_1}} \tag{A.1}
\]

\[
C_{n,t} = \left[ \alpha_2(K_{n,t})^{b_2} + (1 - \alpha_2)(\exp\{s_{n,t}\}h_{n,t})^{b_2} \right]^{\frac{1}{b_2}} \tag{A.2}
\]

\[
K_t = K_{m,t} + K_{n,t} \tag{A.3}
\]

\[
\exp\{\mu_t\}I_t = K_{t+1} - (1 - \delta)K_t + \xi \left( \frac{K_{t+1}}{K_t} - 1 \right)^2 \tag{A.4}
\]

\[
\frac{\alpha_1}{1 - \alpha_1} \left[ \frac{C_{m,t}}{C_{n,t}} \right]^{b_1 - 1} = \frac{1 - \alpha_2}{W_t(1 - \tau_h)} \left[ \frac{C_{n,t}}{h_{n,t}} \right]^{1 - b_2} \exp\{s_{n,t}\}^{b_2} \tag{A.5}
\]

\[
\frac{\alpha_1}{1 - \alpha_1} \left[ \frac{C_{m,t}}{C_{n,t}} \right]^{b_1 - 1} = \frac{\alpha_2}{(1 - \tau_k)r_t + \delta \tau_k} \left[ \frac{C_{n,t}}{K_{n,t}} \right]^{1 - b_2} \tag{A.6}
\]

\[
W_t(1 - \tau_h)(1 - h_{n,t} - h_{m,t}) = \frac{1 - b}{b \alpha_1} C_{m,t}^{1 - b_1} C_t^{b_1} \tag{A.7}
\]

\[
\beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \frac{\exp\{\mu_t\}}{\exp\{\mu_{t+1}\}} \left[ 1 + \frac{\xi}{K_t} \left( \frac{K_{t+1}}{K_t} - 1 \right) \right]^{-1} \right\} \left[ 1 - \delta + \xi \left( \frac{K_{t+2}}{K_{t+1}} - 1 \right) \left( \frac{K_{t+2}}{K_t^2} \right) + \exp\{\mu_{t+1}\}(1 - \tau_k)r_{t+1} + \delta \tau_k \right] = 1 \tag{A.8}
\]

\[
\beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} (1 + R_t)\Pi_{t+1}^{-1} \right\} = 1 \tag{A.9}
\]

\[
\lambda_t = b\alpha_1(1 - h_{n,t} - h_{m,t})^{(1-b)(1-\sigma)}C_{m,t}^{b_1-1}(C_t)^{b(1-\sigma) - b_1} \tag{A.10}
\]

\[
\frac{P^*_t}{P_t} = \left( \frac{1 - \theta \Pi_t^{-1}}{1 - \theta} \right)^{1-\varepsilon} \tag{A.11}
\]

\[
\frac{P_t^*}{P_t} = \frac{x_{1,t}}{x_{2,t}} \tag{A.12}
\]

\[
x_{1,t} = Y_t \frac{\varepsilon}{\varepsilon - 1} RMC_t + \beta \theta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \Pi_{t+1}^\varepsilon x_{1,t+1} \right\} \tag{A.13}
\]
\[ x_{2,t} = Y_t + \beta \theta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \Pi_{t+1}^{\varepsilon-1} x_{2,t+1} \right\} \]  
(A.14)

\[ Y_t = C_{m,t} + I_t + G_t \]  
(A.15)

\[ Y_t = \Delta_t^{-1} \left[ \alpha_3 K_{m,t}^{b_3} + (1 - \alpha_3) h_{m,t}^{b_3} \right]^{\frac{1}{b_3}} \]  
(A.16)

\[ \alpha_3 RMC_t \left( \frac{K_{m,t}}{\Delta_t Y_t} \right)^{b_3-1} = r_t \]  
(A.17)

\[ (1 - \alpha_3) RMC_t \left( \frac{h_{m,t}}{\Delta_t Y_t} \right)^{b_3-1} [\exp\{s_{m,t}\}]^{b_3} = W_t \]  
(A.18)

\[ \Delta_t = (1 - \theta) \left( \frac{P_t^*}{P_t} \right)^{-\varepsilon} + \theta \Pi_t^* \Delta_{t-1} \]  
(A.19)

\[ (1 + R_t) = \beta^{-1} \Pi_t^{\Phi_x} \]  
(A.20)

for all \( t \), for given tax rates and government expenditure. To close the equilibrium definition we furthermore need a specification for monetary policy and the respective law of motion for market- and home productivity and government expenditures.
Figure 1: Impulse responses for the model calibrated as in Table 1, labelled as GHP, and impulse responses of the model without home sector, labelled as Baseline.
Figure 2: Impulse responses of market consumption to a $G$ shock for different values of the elasticity of substitution between home and market goods. All the other parameters are calibrated as in Table 1.
Figure 3: Impulse responses of market consumption to a $G$ shock for different values of price stickiness. All the other parameters are calibrated as in Table 1.
Figure 4: Impulse responses of market consumption to a $G$ shock for different values of capital adjustment costs. All the other parameters are calibrated as in Table 1.
Figure 5: Impulse responses of market consumption to a $G$ shock for different values of the elasticity of inter-temporal substitution. All the other parameters are calibrated as in Table 1. The left and the right panel show the model with and without home sector, respectively.
Figure 6: Impulse responses for the case of distortive taxation. All the other parameters are calibrated as in Table 1. The impulse responses of the model without home sector are labelled as Baseline.
Figure 7: 75th, 50-th and 25-th quantiles of the distribution of impulse responses of market consumption to a $G$ shock for 50000 draws uniform distributions of the following parameters, with their respective bounds: $\theta \in [0, 0.8]$, $\xi \in [0, 25]$, $\rho_g \in [0, 0.99]$, $\Phi_\pi \in [1.1, 1.5]$, $\varepsilon \in [6, 11]$, $G \in [0.05, 0.25]$, and $b_1 \in [0.3, 0.8]$. All the other parameters are chosen as in Table 1. The left hand panel reports the case without home production but with nominal rigidities, while the right hand panel shows the case of home production under flexible prices.
Figure 8: Empirical and theoretical impulse responses after an identified government expenditure shock, $b_1 = 0.8$. 
Figure 9: Empirical and theoretical impulse responses after an identified government expenditure shock, $b_1 = 0.6$. 
<table>
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<tr>
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<tr>
<td>Inverse elasticity of substitution home-market goods</td>
<td>$1 - b_1$</td>
<td>0.25</td>
</tr>
<tr>
<td>Inverse elasticity of substitution capital-labor at home</td>
<td>$1 - b_2$</td>
<td>1</td>
</tr>
<tr>
<td>Inverse elasticity of substitution capital-labor on the market</td>
<td>$1 - b_3$</td>
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</tr>
<tr>
<td>Elasticity of substitution among final goods varieties</td>
<td>$\varepsilon$</td>
<td>11</td>
</tr>
<tr>
<td>Capital adjustment costs</td>
<td>$\xi$</td>
<td>50</td>
</tr>
<tr>
<td>Price stickiness</td>
<td>$\theta$</td>
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<tr>
<td>Inflation reaction coefficient</td>
<td>$\phi$</td>
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<tr>
<td>Depreciation rate of capital</td>
<td>$\delta$</td>
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<tr>
<td>Labor income tax rate</td>
<td>$\tau_h$</td>
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<tr>
<td>Capital Income tax rate</td>
<td>$\tau_k$</td>
<td>0</td>
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<tr>
<td>Steady state government expenditure</td>
<td>$G$</td>
<td>0.0602</td>
</tr>
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Table 1: Baseline calibration