Sectoral Shocks and Home Substitution*

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Abstract

We show that effects of a sectoral shock on the composition of sectoral shares crucially depend on whether the goods produced in the sector are home-substitutable or not. When a productivity shock hits the market sector that produces non-home-substitutable goods (e.g. manufacturing goods), the shock largely affects the composition of consumption shares of market sectors. On the other hand, when a shock hits the market sector that produces home-substitutable goods (e.g. service goods), relocation in shares mainly occur between the sector and the home sector. We compare our results to those of the traditional three-sector model without a home sector, and show that the missing of the home substitution effects predicts completely different implications for the response of consumption shares to sectoral shocks.

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1 Introduction

The home production sector has recently been introduced in several applications of multi-sector models (Rogerson 2008; Ngai and Pissarides 2008; Ngai and Petrongolo 2017; Rendall 2018). This sector creates a new margin, which is typically not observed in national accounts, that can affect the market economy to a large extent. In this paper we study the effects of supply shocks, modeled as changes in prices in a partial equilibrium setting, in shaping the business cycle of consumption shares. Intuitively, when there is a supply shock on goods that have no home production counterparts, the adjustment in consumption shares is substantial, as the margin of adjustment is among goods produced in the market. On the other hand, if the shock is on goods (or services) with home produced counterparts, the relevant margin of adjustment is between market and home services. In this case, market consumption shares should be little affected by this shock.

To provide a quantitative assessment of the effect of supply shocks on consumption shares, a model that can fit the long-run pattern of structural change, including home production, is needed. Typically, the difficulty encountered in doing this is that data on home production are scarce. Therefore, the papers in the previous literature calibrate the model indirectly (Benhabib, Rogerson, and Wright 1991; Greenwood and Hercowitz 1991; McGrattan, Rogerson, and Wright 1997). An exception is the recent paper by Moro, Moslehi, and Tanaka (2017), who estimate a structural change model with home production by using new home production data developed in Bridgman (2016). With this model and its estimation at hand, we are able to study the reaction of consumption shares in the U.S. to a supply shock in manufacturing and to a supply shock in services.

We compare our model's results with those obtained in the model *without* a home production sector. We find that while the response to a manufacturing shock is similar in the two models, a shock to the services sector has a substantially milder effect on consumption shares in the model with a home production sector. Quantitatively, the market service share rises only by 0.4% in the model with a home sector relative to 1.3% in the model without a home sector, after a 10% increase in the service price. Our results therefore indicate that, when predicting the effects of a sectoral shock to the composition of sectoral shares in the economy, one has to take into account home substitutability of the goods produced.

2 Model

This section presents the model of structural change with a home production sector, first proposed in Moro, Moslehi, and Tanaka 2017, which we use in our quantitative exercise.

There is a representative household, whose objective is to maximize her utility. There are five types of good produced in this economy: four consumption goods (agriculture, manufacturing, market services, and home services) and one investment good. The household's preferences are given by

$$u = \sum_{t=0}^{\infty} \beta^t \ln C_t,$$

where β is the subjective discount factor. The composite consumption index C_t is defined as

$$C_t = \left(\sum_{i=a,m,s} \left(\omega^i\right)^{\frac{1}{\sigma}} \left(c_t^i + \bar{c}^i\right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}. \tag{1}$$

where c_t^i denotes consumption of good $i \in \{a, m, s\}$. In (1), the parameter ω^i determines the weight on each good in the household's preference; the parameter $\bar{c}^i$ controls non-homotheticity in preference; and the parameter σ governs the elasticity of substitution between three goods. Service consumption is a composite of market services, c_t^{sm}, and home produced services, c_t^{sh}, as

$$c_t^s = \left[\psi (c_t^{sm})^{\frac{\gamma-1}{\gamma}} + (1-\psi)(c_t^{sh} + \bar{c}^{sh})^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}}. \tag{2}$$

In (2), the parameter γ governs the elasticity of substitution between market and home services and ψ is the share parameter in the service aggregator. We allow for a different income elasticity between market and home services through the parameter $\bar{c}^{sh}$.

Each period, the household is endowed with $\bar{l} = 1$ unit of labor that she splits into working time in the market, l_t^{mk}, paid at wage w_t and working time at home, l_t^{sh}. Also, the household holds the capital stock k_t in the economy, and decides how much to rent in the market, k_t^{mk}, at rate r_t, and how much to use in home production, k_t^{sh}. Then, the household's constraints are given by

$$p_t^a c_t^a + p_t^m c_t^m + p_t^{sm} c_t^{sm} + k_{t+1}^{mk} - (1-\delta) k_t^{mk} + k_{t+1}^{sh} - (1-\delta) k_t^{sh} = r_t k_t^{mk} + w_t l_t^{mk}, \tag{3}$$

$$l_t^{mk} + l_t^{sh} = \bar{l},$$

where p_t^j is the price of good $j \in \{a, m, sm\}$ and δ is the depreciation rate. We normalized the price of the investment goods to be equal to one. The total amount of capital is defined as

$$k_t \equiv k_t^{mk} + k_t^{sh}.$$

The household produces home services through the following technology,

$$c_t^{sh} = A_t^{sh} \left(k_t^{sh}\right)^{\alpha} \left(l_t^{sh}\right)^{1-\alpha}.$$

In this economy, there is a perfectly competitive firm in each market sector $j \in \{a, m, sm\}$ with technology,

$$Y_t^j = A_t^j \left(K_t^j\right)^{\alpha} \left(L_t^j\right)^{1-\alpha}.$$

Finally, there is also a perfectly competitive firm operating in the investment good sector with technology,

$$Y_t^x = A_t^x \left(K_t^x\right)^{\alpha} \left(L_t^x\right)^{1-\alpha}.$$

Moro, Moslehi, and Tanaka (2017) show that the problem of the household can be split into a inter-temporal problem and an intra-temporal problem and that the intra-temporal problem is the one that is responsible for sectoral transformation among four consumption good sectors in the above setup. In addition, Herrendorf, Rogerson, and Valentinyi (2013) (hereafter, HRV) argue that, in estimation, there is a clear advantage in only focusing the intra-temporal problem in order to avoid a misspecification of the investment sector. With this in mind, we focus on the following intra-temporal problem and analyze how sectoral shocks to technologies $\left\{A_t^j\right\}_j$ affect the sectoral composition through prices $\left\{p_t^j\right\}_j$, in the next section.

In the Intra-Temporal Problem, the household solves:[1]

$$\max_{\left\{c_t^a, c_t^m, c_t^{sm}, c_t^{sh}\right\}} \left(\sum_{i=a,m,s} \left(\omega^i\right)^{\frac{1}{\sigma}} \left(c_t^i + \bar{c}^i\right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

subject to

$$c_t^s = \left[\psi (c_t^{sm})^{\frac{\gamma-1}{\gamma}} + (1-\psi)(c_t^{sh} + \bar{c}^{sh})^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}},$$

and

$$p_t^a c_t^a + p_t^m c_t^m + p_t^{sm} c_t^{sm} + p_t^{sh} c_t^{sh} = P_t C_t - \sum_{i=a,m,s} p_t^i \bar{c}^i - p_t^{sh} \bar{c}^{sh} \equiv E_t.$$

3 Calibration

We have nine parameters to be calibrated before conducting the main analysis. To determine the parameter values, we follow the previous studies that estimate structural change models with the U.S. data. First, we set the value of the parameter σ to zero, which governs

[1]See Moro, Moslehi, and Tanaka (2017) for the derivation.

Table 1 – Parameter Values Calibrated

Name	σ	$\bar{c}^a$	$\bar{c}^s$	$\bar{c}^{sh}$	ω^a	ω^m	ω^s	γ	ψ
Value	0.0	-129.0	4360.8	-5135.3	2.6×10^{-3}	15.7×10^{-2}	8.4×10^{-1}	2.3	62.5×10^{-1}

the elasticity of substitution across agricultural good, manufacturing good, and aggregate services. Using the U.S. data from 1947 through 2010, Moro, Moslehi, and Tanaka (2017) estimate the structural transformation model with a home sector and find that σ is close to zero. Similarly, HRV (2013) also estimate σ to be close zero with their three-sector model without a home sector. The parameters $\left\{\bar{c}^a, \bar{c}^s, \bar{c}^{sh}\right\}$ are the non-homotheticity terms that determine the income effects of the model. The parameters $\{\omega^a, \omega^m, \omega^s, \psi\}$ are the weight parameters in the utility function that determine the shares of goods in the total consumption. We calibrate those seven parameters to the estimates in Moro, Moslehi, and Tanaka (2017).

Finally, γ is the parameter most relevant to this paper's exercise, which governs the elasticity of substitution between market and home services. In the literature, one set of studies estimates the parameter γ by using fluctuations of aggregate home hours over the business cycles (McGrattan, Rogerson, and Wright, 1997; Chang and Schorfheide, 2003). Another set of studies, instead, uses household micro data for home hours (Rupert, Rogerson, and Wright, 1995; Aguiar and Hurst, 2007). Moro, Moslehi, and Tanaka (2017) review this literature, and report the range of the estimates for the parameter γ. We follow the choice of the value in Moro, Moslehi, and Tanaka (2017), and set γ to 2.3.

4 Response of the Model to Sectoral Shocks

In this section we study how the calibrated model behaves when there is a shock to relative prices. We compare our model with the traditional model of structural transformation in HRV (2013), in which there are only three consumption good sectors, and no home production sector. It is worth noting that our model becomes identical to that of the three-sector model when ψ is set to one. We set the parameter values of the three sector model to those in HRV (2013).[2] In each model, we introduce a shock implying a 10% increase in the manufacturing good price or the market service price. These shocks can be considered as a negative productivity shock in either sector. We consider the year 2010 as the benchmark

[2] Specifically, we set the parameters of the three-sector model without a home sector to those of the specification "(2)" in Table 3 in HRV (2013). HRV (2013) find the parameter values by estimating their three-sector model with the U.S. data for the same time-period as that of Moro, Moslehi, and Tanaka (2017).

year, and set the pre-shock sectoral prices, $\{p_t^a, p_t^m, p_t^{sm}, p_t^{sh}\}$, and household's total extended consumption expenditure, E_t, to the values in that year.[3] Then, we simulate the movements of the sectoral shares in the economy after the shock hit. These results are shown in Figures 1 and 2.

Comparing the responses of the two models to the price shocks, first note that, in both models, σ is zero, meaning that the utility function takes a Leontief specification in terms of agriculture, manufacturing, and aggregate services. This, in the model without home production, implies that quantities in equilibrium are little affected by changes in prices, so that the share of manufacturing (or services) increases and the other shares decline after the rise in the price of manufacturing (or services). See the model *without home* in Figures 1 and 2 on this point. This is also true for the model with home production, when the shock is on the manufacturing price as shown by the model *with home* in Figure 1.

However, when the shock is on the market service price, the result is different. As shown in Figure 2, the rise in the share of market services becomes relatively smaller in the model *with home* than in the model *without home* because the household substitutes market services with home services in the former. Quantitatively, the market service share rises only by 0.4% in the model *with home* relative to 1.3% in the model *without home*. This substitution effect is also reflected in the decline of total consumption expenditure in the market as shown in the last panel in Figure 1. As a result, the variations of all market shares are smaller, compared to the case with no home production: the agricultural share changes by +1.0% in the model *with home* and by -2.1% in the model *without home*. The manufacturing share changes by -2.4% in the model *with home*, while it changes by -6.8% in the model *without home*.

In summary, when there is a shock to the price of services, substitution between market and home services occurs. Therefore, our model exhibits a share movement which is substantially different from the traditional three-sector model in the previous literature.

[3] See Moro, Moslehi, and Tanaka (2017) for the complete description of the data construction and sources.

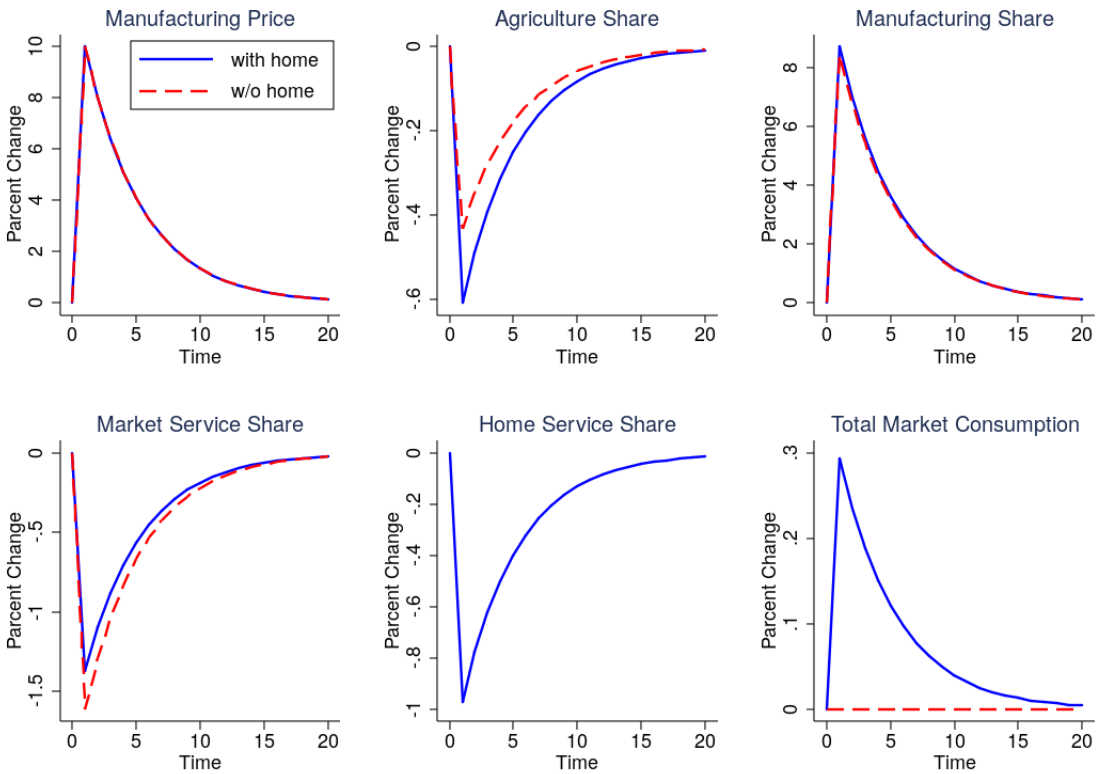

FIGURE 1 – Effect of an Increase in *Manufacturing Price* on Sectoral Shares

Note: All the shares are calculated relative to total market consumption, in order to make the results in our model and HRV (2013) comparable.

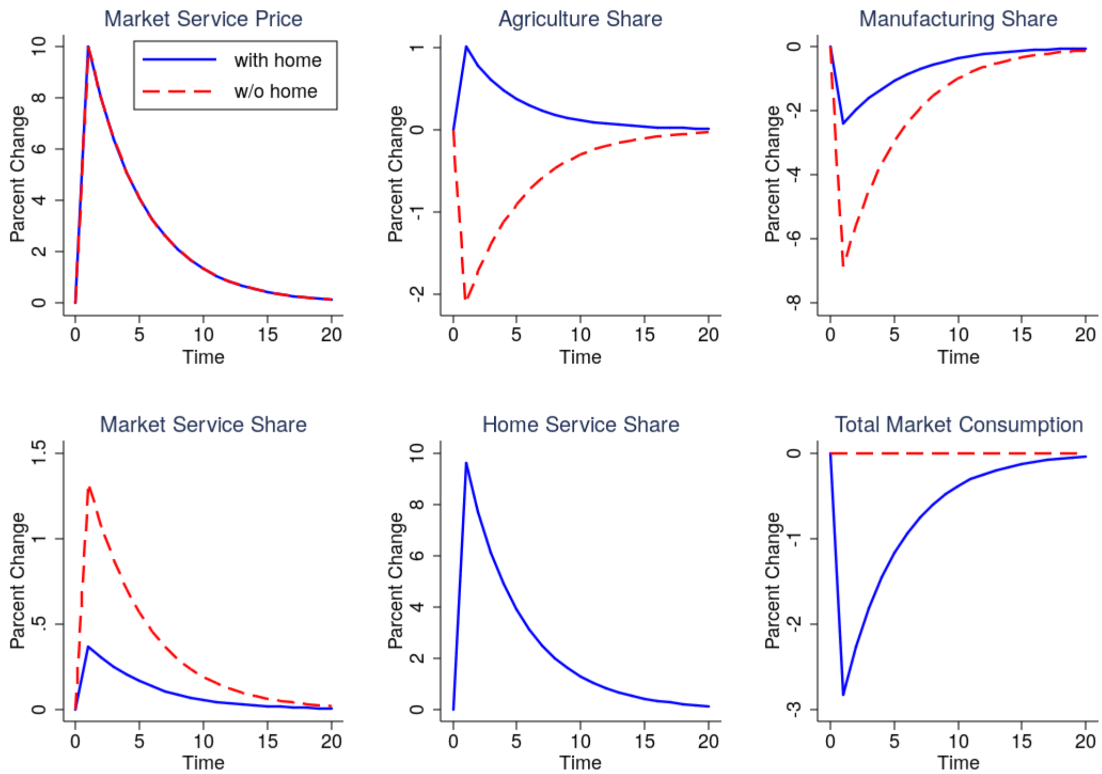

FIGURE 2 – Effect of an Increase in Market Service Price on Sectoral Shares

Note: All the shares are calculated relative to total market consumption, in order to make the results in our model and HRV (2013) comparable.

5 Conclusion

In this paper we used a state of the art model of structural transformation with a home produced sector calibrated to the U.S. economy to show how market consumption shares are affected by manufacturing and service sectors' supply shocks. As home production is a substitute product for market services, a supply shock to the market service sector does not affect market sectoral composition to a large extent. The opposite occurs when a manufacturing shock hits. Our results of share movements also imply that, once the model is extended to a general equilibrium model framework, the patterns of relocation of capital and labor after a shock hits crucially depend on home substitutability of the goods produced in the sector. While this exercise potentially has important policy implications, we leave it for future work.

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