Demand Induced Fluctuations*

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Abstract

We build a variation of the neoclassical growth model in which households increased desire to save generate recessions. Our economy features three departures from the standard model: (1) goods markets (for nontradables) require active search from households wherein increases in consumption expenditures increase measured productivity; (2) adjustment costs make it difficult to expand the tradable goods sector by reallocating factors of production from nontradables to tradables; (3) labor markets have Nash bargaining wage setting and Mortensen-Pissarides search and matching frictions labor markets. These departures provide a novel quantitative theory to explain recessions like those in southern Europe without relying on technology shocks.

Keywords: Great Recession; Paradox of thrift; Endogenous productivity
JEL classification: E20, E32, F44

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1 Introduction

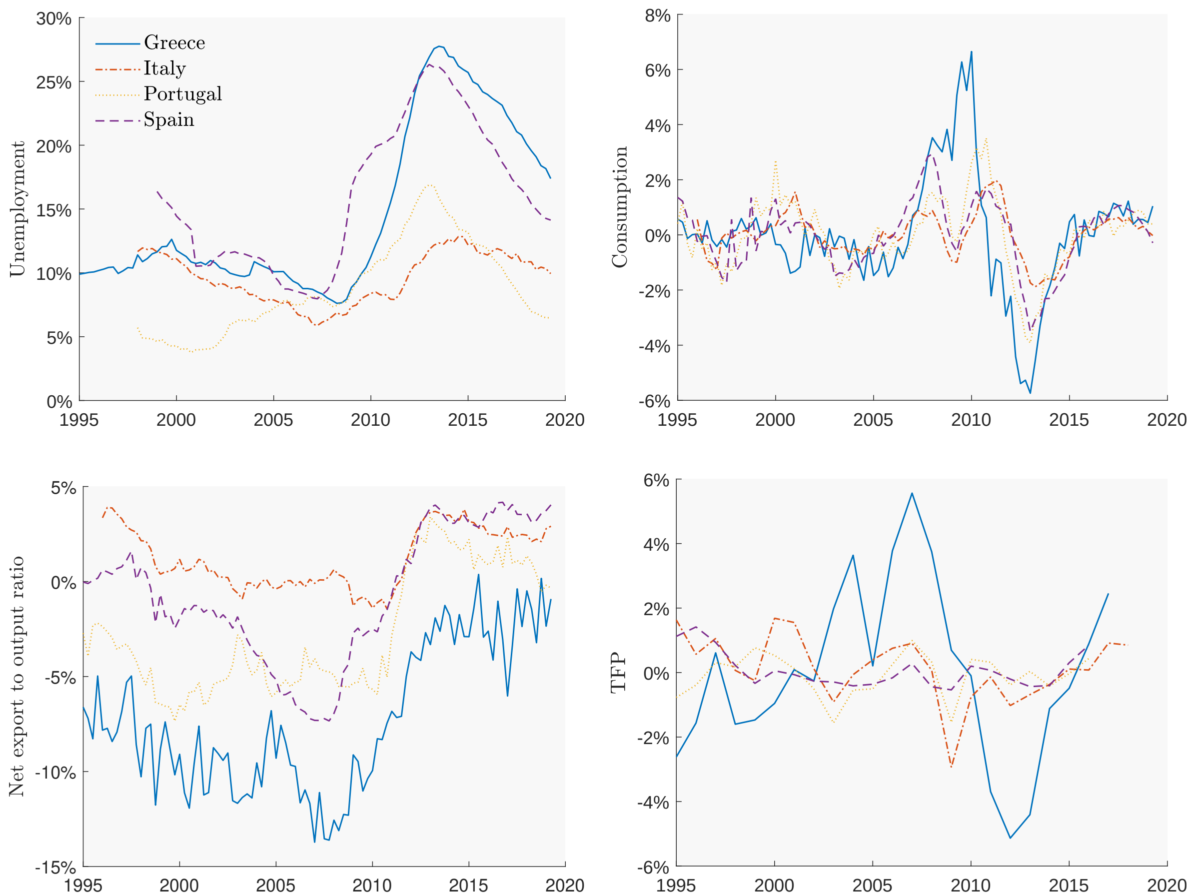
We build an equilibrium neoclassical real business cycle model where an increase in the desire to save and to work generates a recession. This is exactly the opposite of what happens in the standard neoclassical real business cycle model. We make three changes to the standard model, that we consider mild, and that we detail below.

We think that achieving this result within a neoclassical structure is important for three reasons. One is that our changes accommodate the notion that higher savings, i.e. lower consumption may be detrimental for the performance of the economy, which is the prevailing popular belief (among policy makers, the popular press and pundits of all persuasions). The changes in household behavior can be the result of (temporary but persistent) changes in preferences which is the form that we model them, but can also be the result of other exogenous changes that induce a negative wealth effect to which households respond by saving more and willing to work harder. A second reason is that our model delivers the same features that countries in Southern Europe experienced during the Great Recession (a sharp increase in unemployment, a large decrease in consumption, increases in the ratio of net exports to output and a mild reduction in total factor productivity (TFP)) as can be seen in Figure 1. Finally, this result shows how demand induced fluctuations can be modeled with neoclassical notions of equilibrium without having to appeal to disequilibrium notions such as those present in New Keynesian models where prices do not adjust to clear markets and instead present arbitrary sluggishness.

To achieve a recession out of an increased willingness to save and to increase work effort is neither easy nor intuitive within the context of a neoclassical growth model. Consider the resource constraint, $C_t + I_t = Y_t = A_t F(K_t, N_t)$, where C_t denotes consumption, I_t investment, Y_t output, K_t capital, N_t labor, A_t is an exogenous object that determines productivity, and F is a constant returns to scale neoclassical production. A reduction in consumption can be trivially achieved by an increase in investment without changing inputs of production. Moreover, an increased willingness to work (which is the case that we explore in this paper) together with having capital predetermined induces higher, not lower, output today and also in future periods as investment translates into higher future capital.

The changes that we make to revert this immediate implication of the standard model operate through three channels. There is a direct reduction of output given a certain amount of desired expenditure that works via a drop in TFP due to search frictions in the goods market. The second channel is the existence of adjustment costs in sectors that are not subject to the depressed demand. The third channel takes away from households the decision of how much to work and places it solely on the hands of firms while at the same time having a wage setting process that limits the reduction of wages. These channels reduce the incentives of firms to hire workers as a consequence of the reduction in consumption, which can in

FIGURE 1: Aggregate Economic Variables in Southern European Countries



Notes: The data are from OECD National Accounts. Output, consumption, and net exports refer to Gross Domestic Product, Final Consumption Expenditure, and External Balance of Goods and Services. TFP is multifactor productivity. The unemployment rate is for all persons, aged 15 and over.

turn generate a persistent recession. To make these mechanisms transparent and to make it more directly applicable to the Southern European experience, we pose the environment as a small open economy avoiding all concerns about movements in interest rates.[1] The saving/investment margin is now settled through trade deficits or surpluses and the implied changes in the net foreign asset position of the country.

We label the first channel as *endogenous choice of varieties*, implies that a reduction in consumption reduces profits of firms, something that operates via an *endogenous* reduction of productivity. We follow here recent work in Huo and Ríos-Rull (2014) who develop these ideas in the context of an heterogeneous

[1]The same logic with mild modifications extends to a system of closed economies. For example, in Bayer, Lütticke, Pham-Dao, and Tjaden (2019), variations in the government bond supply accommodate stable interest rates in a closed economy.

agents model where a shock with negative effects on wealth induces lower consumption and lower productivity. As a consequence, firms want to hire less workers to produce consumption goods. This mechanism relies on the existence of many varieties of goods and of household's consumption being a combination of the number of varieties of goods consumed and of the quantity consumed of each variety. For suitably chosen preferences, when households want to cut their consumption they do so by reducing the number of varieties that they consume and the quantity of each variety. Finding varieties requires search effort and the reduction of the number of varieties, and hence of search effort, yields idle capacity on the firms. That is, the occupancy rates for firms are tightly related to the number of consumers that use each variety. As a consequence, outputs and profits can fall even with the amount of inputs unchanged, which induces firms to cut employment.

The endogenous choice of varieties is related to, but quite different from, capacity utilization as used in the literature since at least Greenwood, Hercowitz, and Huffman (1988). In the endogenous choice of varieties the missing element in the determinant of productivity is household effort, while inputs of production are used at full capacity. In the capital utilization framework there is no notion of households engagement in the determinants of the quantity of output and it is extra effort of inputs of production what is responsible for the increased TFP, extra effort that has to be rewarded. This distinction becomes clear in the endowment economy presented in Section 2.

The predictions of our model for the relation of consumption and the number of varieties are consistent with the empirical findings of Jackson (1984) and especially Li (2020): consumers increase consumption by increasing both the number varieties and the quantity of each variety. In fact, Li (2020) shows that for the vast majorities of goods, both varieties and quantities are increasing in consumption expenditure, and that the Engel curve for varieties is upward sloping. The baseline model with a representative consumer displays no income dispersion, and the predictions of the model are only for time series. However, in an extended version of the model that accommodates financial frictions, employed households members consume more varieties than unemployed members. The time-series and cross-section predictions of the model are a clear positive correlation between the number of varieties and households' income.

The second channel in our model is that the inputs of production that are freed from usage in consumption goods cannot be easily used towards investment or net exports, making it difficult for the economy as a whole to save. This is achieved via the existence of differentiated sectors (in our case tradables and nontradables) and the existence of adjustment costs to increase production and of decreasing returns to scale in the tradables sector. This channel is also at work in Kehoe and Ruhl (2009), where they argue that without labor adjustment costs there is too much shifting of resources into the tradable sector. Alessandria, Pratap, and Yue (2013) find that frictions in exports are necessary to match the gradual increase in exports that follows a devaluation. Extreme versions of the existence of adjustment costs can be found in the work of Mendoza (2001), Schmitt-Grohe and Uribe (2011), and Farhi and Werning

(2012), where tradable goods are given exogenously.

The change to standard real business cycle models that operates on the labor market is to pose search frictions à la Mortensen–Pissarides and Nash bargaining for wage setting. This feature has a long tradition within the real business cycles literature since at least Merz (1995) and Andolfatto (1996).[2] With these labor market frictions not all households can work, as it takes time to find a job. Perhaps more importantly, the wage is determined after the worker and the firm meet which makes wage reductions difficult even if workers have become more eager to get a job. There is such a wide body of literature on frictional labor markets in business cycle models that we do not attempt to give a summary here. We simply point out a particular kind of externality in our model economy when different sectors do not perfectly synchronize. Firms in the tradable sector do not face a lower demand and are willing to expand their labor force, but it makes hiring even more costly for firms in the larger and suffering nontradable sector due to a tighter market tightness, resulting in a bigger loss of aggregate output.

There is a large literature that engineers recessions induced by an increased incentive to saving by assuming nominal rigidities. Eggertsson (2011), Christiano, Eichenbaum, and Rebelo (2011), Eggertsson and Krugman (2012), Correia, Farhi, Nicolini, and Teles (2013) do so by assuming a shock to the discount factor. Rendahl (2016) and Schmitt-Grohe and Uribe (2012) assume instead a decrease in confidence while Basu and Bundick (2017) use increased uncertainty. In all these papers insufficient demand triggers a recession because the economy is stacked at the zero lower bound on the nominal interest rate and there are either rigid prices or rigid wages. As explained in Basu and Bundick (2017), with price rigidity, output becomes demand determined.[3] A large drop of the wage rate helps clear the labor market and the associated increase of the price markup is consistent with firm optimization. The marginal product of labor is no longer the same as the marginal rate of substitution, effectively breaking down the intratemporal Euler condition in the standard real business cycle models. When the nominal interest rate hits the zero lower bound, its stimulating role is no longer effective and the recession is more severe. Although our paper shares the same view with this literature that a recession is the result of insufficient demand, it does not hinge on the economy being stacked at the zero lower bound on the nominal interest rate nor on the existence of rigid prices or wages. Instead, we provide a neoclassical view of how increased savings generate a recession, which is based in physical frictions and not in frictions in the working of markets.

There is also a set of papers that explore how recessions can be induced by tightened financial frictions. This is a popular micro-founded rationale for the increased incentive to save by increased difficulties to borrow by some households in in a heterogeneous-agent economy. Mian and Sufi (2010) and Mian and

[2]Still, at the time the publication of Cooley (1995) it was a fairly new idea with only a collateral reference to Andolfatto (1996) (in Danthine and Donaldson (1995)) and none to Merz (1995).

[3]This requires that the markups are large enough to ensure that at the fixed prices the supply side is willing to produce the quantities demanded. See Huo and Ríos-Rull (2019) for the problems associated to the assumption that allocations are demand determined when wages are rigid (the same logic would apply to rigid prices).

Sufi (2012) provide evidence of this link using county-level data to show that household demand is crucial in explaining aggregate economic performance and that it is also closely linked with households' financial conditions. Guerrieri and Lorenzoni (2017) consider a shock to households' borrowing capacity in an Aiyagari-type model. If combined with nominal rigidities, the financial shock can potentially push the economy into a liquidity trap and result in a decline in output (although typically this mechanism induces an increase in labor). Eggertsson and Krugman (2012) also study the effect of an exogenous reduction of the debt limit and highlight a Fisher deflation mechanism. Midrigan and Philippon (2011) focus on the home equity borrowing issue. With nominal rigidities, they show that a drop in the leverage ratio reduces the liquidity of households and, correspondingly, their demand. Bayer, Lütticke, Pham-Dao, and Tjaden (2019) build a heterogeneous-agent New Keynesian model and show that an increased uncertainty faced by individual households can depresse demand and lead to a recession. Huo and Ríos-Rull (2014) is to our knowledge the only paper within the neoclassical context where a drop in demand generates a fall in output and employment. It includes some of the mechanisms described in this paper (except for wage rigidity instead of Nash bargaining) within a heterogeneous agents economy with assets in fixed supply (houses) so a tightening of financial markets induce a large negative wealth effect that reduces consumption, and with it the economy plunges into a recession.

In terms of goods market frictions, Alessandria (2009) uses endogenous variation in households' shopping time to explain the deviation from law of one price. Kaplan and Menzio (2013), Petrosky-Nadeau and Wasmer (2015), and Michaillat and Saez (2015) explore the interaction among goods market and labor market frictions in shaping business cycle fluctuations. A common feature in the aforementioned work is that firms' capacity or the probability of selling their products stay constant over the business cycle, which is a major difference compared with our work. The endogenous choice of varieties is close but different to the model of endogenous productivity in Bai, Ríos-Rull, and Storesletten (2011). There, consumption is also subject to search frictions that require effort. However, search effort acts as a substitute of work effort implying that negative wealth effects increase productivity by inducing households to increase their search effort. Endogenous choice of varieties, on the other hand, poses the opposite implication in the presence of wealth effects for households, because less consumption requires less search effort productivity actually goes down when consumers feel poorer or want to delay gratification by cutting consumption.

The novelty of the endogenous choice of varieties induces us to dedicate a small section with a simple example that illustrates how it works in Section 2. We then move on to lay out the environment in a form suitable for quantitative analysis in Section 3. We map the model to data in Section 4. The main analysis of the baseline economy is in Section 5. We describe the quantitative importance of the mechanisms that we develop in this paper (which we deem to be large) in Section 5.1. We continue by exploring how the recession is either dimmed or it disappears when we remove each of the channels that we have changed relative to the standard model: goods market frictions in Section 5.2, adjustment costs in Section 5.3 and labor market frictions in Section 5.4. We also look at how the answers of the model change when we pose alternative calibration targets in Section 5.5. We also ask what is the response of the economy to other types of shocks: Section 6.1 describes what happens when the baseline economy becomes suddenly poorer (a wealth destruction shock if one could use such an expression). Section 6.2 extends the model to accommodate a notion of financial shocks as the trigger to households' increased desire to save without the need to abandon the representative agent abstraction by posing difficulties to smooth the consumption of the household members who are unemployed. Section 7 concludes.

2 A Simple Model to Illustrate the Endogenous Choice of Varieties

We start by posing a two-period endowment model to illustrate how the goods market friction works, and how it translates a depressed demand into lower output. Households care about two sets of goods in the first period, which we call tradables and nontradables, and about the amount of tradable goods saved for the second period. The tradable goods market is frictionless, but nontradables market are subject to search and matching frictions which we explain in detail now.

There is a continuum of measure one of nontradable consumption varieties. Households have to exert search effort, d, to find varieties of nontradables that they consume before they can make any purchases of that variety. Households then choose how many varieties, $\mathcal{I}$, of nontradables and the quantity of each variety, $c_{N,i}$, to consume. A Dixit-Stiglitz aggregate of consumption of all varieties combined them with consumption of tradables à la equal weight Cobb-Douglas with separable search effort form the utility function yielding

$$u\left(c_T, \{c_{N,i}\}_{i=1}^{\mathcal{I}}, d\right) = \left(\int_0^{\mathcal{I}} c_{Ni}^{\frac{1}{\rho}}\, di\right)^{\frac{\rho}{2}} c_T^{\frac{1}{2}} - d/4 \equiv \sqrt{c_N\, \mathcal{I}^{\rho}}\, \sqrt{c_T} - d/4.$$

We denote by $\Psi^d(Q)$ the probability that a unit of search effort finds a variety, where Q is market tightness in the goods market. Households have an endowment of one unit of the tradable good in the first period, and they can borrow or save b' at a zero interest rate. They also own the nontradable-producing firms. The household's problem is then

$$\max_{c_T, \mathcal{I}, c_N, d, b'} \sqrt{c_N \mathcal{I}^{\rho}}\sqrt{c_T} - \frac{d}{4} + \beta b',$$

subject to

$$c_T + P\, \mathcal{I}\, c_N + b' = \pi + 1,$$

$$\mathcal{I} = d\, \Psi^d(Q),$$

where π is the profit from the firms in the nontradable sector. Here, we have used the property that in a symmetric equilibrium, for a variety i, $c_{N,i} = c_N$ and $p_i = P$.[4]

A continuum of measure one of firms produce nontradables, and each one of those firms has a measure one of locations endowed with one unit of nontradables. A location has to be found by a household to make sales, an event that happens with probability $\Psi^f(Q)$. The profit of a nontradable firm is $\pi = P\Psi^f(Q)c_N$. Because search is not directed, firms will set the price for their goods in a way such that all the goods at a location will be sold once visited by a consumer.

Locations and households are matched in the nontradable goods market according to matching function $M(D,T) = D^\alpha T^{1-\alpha}$, where D is the aggregate search effort of households and T is the total measure of locations that is equal to one. As a result, in equilibrium, $\Psi^d(Q) = D^{\alpha-1}$, $\Psi^f(Q) = D^\alpha$, and nontradable output in the first period is given by $Y_N = D^\alpha$. Hence, households' consumption choice and their associated search effort matter for the determination of aggregate output. Now we proceed to determine the output and to explore its relationship with the saving incentive captured by β.

Households' first-order conditions lead to $(\rho-1)c_N \mathcal{I}^{\rho-1} = \frac{\beta}{\Psi^d(Q)}$, and noting that the assumption that nontradable goods endowment is 1, it follows that

$$\frac{\rho-1}{\beta}\mathcal{I}^{\rho-1} = \frac{1}{\Psi^d(Q)}$$

The left-hand side represents the marginal gain of having one additional variety, and the right-hand side is the associated search cost. With a larger β, ceteris paribus, and consumers tend to search less as current consumption becomes relatively less important.

In general equilibrium, when consumers collectively reduce their search effort, it also makes search less costly because the probability of finding a location becomes higher. Setting $D = d$, nontradable output can be expressed as

$$Y_N = D^\alpha \propto \beta^{-\frac{\alpha}{1-\alpha\rho}}.$$

Therefore, with a moderate matching elasticity, $\alpha\rho < 1$, nontradable goods output decline after a positive shock to households' discount rate.

To see what is special in this economy, note that in standard models, $Q = 1$ and the relative price of the two consumptions adjusts to clear the market. Since the interest rate is fixed, preferences determine savings. If both types of consumption are complements, when households want to save more, say, because of bigger β, a decrease in the price of the nontradables maintains market clearing, which in standard models occurs without any change in its quantity. This is not the case in our economy. Output of nontradables

[4] In fact we have ignored the issue of the determination of the price of nontradables because it is not consequential to the point that we want to make here. The price of varieties is set by the monopolistic firms taking into account the elasticity of demand. We go in detail over this issue in Section 3.

can decrease despite using all factors of production. With the preferences that we pose, households reduce nontradable consumption by reducing the number of varieties as well as the amount consumed of each variety. In this simple economy, the amount consumed of each variety is predetermined so it cannot drop, but the number of varieties that each consumer purchases does drop, and hence so does total output because the economy is now operating at a lower capacity.

This simplified version of our economy illustrates how an increase in savings generates a reduction in output via a reduction in measured TFP without either technology or the measured inputs changing. It is the search efforts of households that decrease. Here, only current profit decreases. If this mechanism were persistent, future profits would also decrease, which can result in a paradox of thrift. We next build these ideas into a growth model suitable for dynamic quantitative analysis.

3 The Baseline Economy

Our baseline economy poses a small open economy with the interest rate set by the rest of the world. There is a representative household, or family with a measure one of individual members, all of whom can work. The household fully insures all of its members.

Goods There are two types of goods: tradables, which can be imported and exported and used for consumption and investment, and nontradables, which can be used only for local consumption. Nontradables are subject to additional frictions similar to those in Section 2: There is a measure one of varieties of nontradables $i \in [0,1]$. Each variety i is produced by a monopoly firm that owns a continuum of locations. The production in each location uses its own capital and labor and a standard constant returns to scale (CRS) technology, $F^N(k,n)$. Firms post prices and have to deliver the amount of goods demanded at that price.

Each period, households have to search for varieties. We denote the aggregate measure of shopping effort, or shoppers for short, as D. The total number of matches between shoppers and firms is determined by a matching function $M^g(D,1)$. Denote market tightness in the goods market by $Q^g = \frac{1}{D}$. The probabilities that a shopper finds a location and a location is filled by a shopper are given by

$$\Psi^d(Q^g) = \frac{M^g(D,1)}{D}, \qquad \Psi^f(Q^g) = \frac{M^g(D,1)}{1}. \tag{1}$$

Firms in the tradable goods sector operate in a standard competitive market, and we use tradables as the numeraire. Let the aggregate production function of tradables be given by $F^T(k,n)$.

Labor Market Work is indivisible, and all workers are either employed or unemployed. The labor market has a search friction à la Mortensen and Pissarides: firms have to post job vacancies, and unemployed workers are matched to those vacancies via a neoclassical matching function. There is a single labor market where all firms post vacancies, denoted as V_N by nontradable producers and V_T by tradable producers. The number of new matches is given by a CRS matching function $M^e(U, V)$, where U is the unemployment rate and $V = V_N + V_T$ is the total number of vacancies. The probability of finding a job for an unemployed worker and the probability of a job vacancy being filled are given by

$$\Phi^w(Q^e) = \frac{M^e(U, V)}{U}, \qquad \Phi^f(Q^e) = \frac{M^e(U, V)}{V}, \tag{2}$$

where $Q^e = \frac{V}{U}$ is labor market tightness. An employed worker faces a constant probability λ of job loss. Wage determination will be discussed below.

Preferences The representative household cares about an aggregate of nontradable consumption as in Section 2, tradable consumption, shopping effort, and the fraction of its members that work n. The aggregate consumption basket, c_A, is valued via an Armington aggregator of tradables and nontradables. The period utility function is given by $u(c_A, d, n)$. Even though the search and matching features imply that workers are rationed, the disutility of working matters for wage determination. Households discount the future at rate β and are expected utility maximizers.

Asset Markets Households own the firms inside their own country that yield dividends $\pi_N + \pi_T$ and receive labor income. Households have access to (noncontingent) borrowing and lending from abroad at an internationally determined interest rate r. We denote the foreign asset position by b.

The state vector for a household, in addition to the aggregate state S to be specified later, is the pair (b, n), its assets and the fraction of its members with a job. Households take as given the prices of each variety p_i, the wage w, the probability of finding a variety Ψ^d, the probability of finding a job Φ^w, and the firms' dividends, all of which are equilibrium functions of the state.

Household's Problem We can write the recursive problem of the household as

$$V(S, b, n) = \max \;\; u(c_A, d, n) + \beta\, \mathbb{E}\left[V(S', b', n')\right],$$

subject to

$$\int_0^{\mathcal{I}} p_i\, c_{N,i}\, di + c_T + b' = (1+r)b + wn + \pi_N + \pi_T, \tag{3}$$

$$\mathcal{I} = d\, \Psi^d(Q^g), \tag{4}$$

$$n' = (1-\lambda)n + \Phi^w(Q^e)(1-n), \tag{5}$$

$$S' = G(S). \tag{6}$$

The household's budget constraint is (3). The requirement that varieties have to be found, which requires search effort d, and depends on the tightness in the goods market is (4). The evolution of the household's employment is (5), and condition (6) is the rational expectations requirement.

We define standard aggregates of nontradable consumption bundles and prices as:

$$c_N = \left[\frac{1}{\mathcal{I}} \int_0^{\mathcal{I}} c_{N,i}^{\frac{1}{\rho}}\, di\right]^{\rho}, \qquad P = \left[\frac{1}{\mathcal{I}} \int_0^{\mathcal{I}} p_i^{\frac{1}{1-\rho}}\, di\right]^{1-\rho}.$$

The demand schedule for the goods from a particular variety (or firm) i,is given by

$$c_{N,i} = \left(\frac{p_i}{P}\right)^{\frac{\rho}{1-\rho}} c_N. \tag{7}$$

A straightforward derivation yields the following first-order conditions for the optimal consumption choices

$$u_{c_N} = P\, \mathcal{I}\, u_{c_T}, \tag{8}$$

$$u_{c_T} = (1+r)\, \beta\, \mathbb{E}\left[u'_{c_T}\right], \tag{9}$$

$$u_{\mathcal{I}} = P\, c_N\, u_{c_T} - \frac{u_d}{\Psi^d(Q^g)}. \tag{10}$$

Given their relative price, Equation (8) equals the marginal utility of tradable and nontradable consumption goods. Equation (9) is the standard Euler equation. Equation (10) is unique in our environment, and it determines the trade-off between the number of varieties and the quantity consumed of each variety: since $\rho > 1$, increasing $\mathcal{I}$ is more efficient than increasing c_N, but searching for different firms is costly. An implication of this equation is that (depending on the details of the utility function), increases in consumption imply an increase of both the amount consumed of each variety and the number of varieties.

Firms in the Nontradable Goods Sector Firms post prices in each location. If a shopper shows up, it chooses how much of the good to buy according to the demand schedule derived earlier. We rewrite this demand schedule as a function that depends explicitly on both the aggregate state and goods prices:

$$C(p, S) = \left(\frac{p}{P}\right)^{\frac{\rho}{1-\rho}} c_N. \tag{11}$$

To produce the goods, firms have a CRS production function that uses capital k and labor n. Recall that there is also a search friction in the labor market, so firms need to post vacancies at cost κ per unit in order to increase their labor the following period. Both investment and vacancies use tradable goods. The individual firm's state is (k, n), and its problem is

$$\Omega^N(S, k, n) = \max\ \Psi^f[Q^g]\, p\, C(p, S) - wn - i - v\kappa + \mathbb{E}\left[\frac{\Omega^N(S', k', n')}{1+r}\right],$$

subject to

$$\begin{aligned} C(p, S) &\leq F^N(k, n), \\ k' &= (1-\delta)k + i - \phi^N(k, i), \\ n' &= (1-\lambda)n + \Phi^f(Q^e)v, \\ S' &= G(S), \end{aligned}$$

where $\phi^N(k, i)$ is a capital adjustment cost, which slows down the adaptation of firms to new conditions. Note that both capital and employment are predetermined, and therefore firms have to set the price such that demand does not exceed output. In equilibrium, all firms choose the same price, i.e., $p_i = P$ for all $i \in [0, 1]$.

Firms in the Tradable Goods Sector Unlike firms in the nontradable goods sector, firms in the tradable goods sector operate in a frictionless, perfectly competitive environment. To accommodate the possibility of decreasing returns to scale, we pose that in addition to capital and labor, firms also need to use another factor, land, available in fixed supply, as an input of production. Without loss of generality, we assume that there is a firm that operates each unit of land. There are also adjustment costs to expand capital and employment, given by functions $\phi^{T,k}(k, i)$ and $\phi^{T,n}(n', n)$, which makes it difficult for this sector to expand quickly. The problem of the firms in the tradable goods sector is

$$\Omega^T(S, k, n) = \max\ F^T(k, n) - wn - i - v\kappa - \phi^{T,n}(n', n) + \mathbb{E}\left[\frac{\Omega^T(S', k', n')}{1+r}\right],$$

subject to

$$
\begin{aligned}
k' &= (1-\delta)k + i - \phi^{T,k}(k,i), \\
n' &= (1-\lambda)n + \Phi^f(Q^e)v, \\
S' &= G(S).
\end{aligned}
$$

Wage Determination The wage rate is determined via Nash bargaining. Unlike in Krusell, Mukoyama, and Şahin (2010) and Nakajima (2012), where agents internalize the effect of additional saving on their bargaining position, here we assume that individual workers and firms take the wage as given and act as though a worker-firm pair like themselves bargain over the wage rate.[5] The value of an additional employed worker for the household with wage $\widetilde{w}$ is

$$
\widetilde{V}_n(\widetilde{w}, S) = \widetilde{w} u_{c_T} + u_n + \beta(1 - \lambda - \Phi^w(Q^e))\mathbb{E}\left[V_n(S')\right],
$$

where $V_n(S) = \widetilde{V}_n(w, S)$ and w is the equilibrium wage with under state S. The values of an additional worker for a firm in the nontradable and tradable goods sector with wage w are

$$
\begin{aligned}
\widetilde{\Omega}_n^N(\widetilde{w}, S) &= \Psi^f(Q^g) P F_n^N \frac{1}{\rho} - \widetilde{w} + \frac{1-\lambda}{1+r}\mathbb{E}\left[\Omega_n^N(S')\right], \\
\widetilde{\Omega}_n^T(\widetilde{w}, S) &= F_n^T - \widetilde{w} - \phi_n^{T,n} + \frac{1-\lambda}{1+r}\mathbb{E}\left[\Omega_n^T(S')\right],
\end{aligned}
$$

where $\Omega_n^N(S) = \widetilde{\Omega}_n^N(w, S)$ and $\Omega_n^T(S) = \widetilde{\Omega}_n^T(w, S)$. Firms may not value workers equally, that is, $\widetilde{\Omega}_n^T$ may not be the same as $\widetilde{\Omega}_n^N$. To obtain a unique wage, we assume that the wage is the outcome of a bargaining process between a representative worker and a weighted representative of firms, with weights given by the employment share of each sector. With these elements, the wage rate in equilibrium can be determined via a Nash bargaining problem

$$
w = \max_{\widetilde{w}} \left[\widetilde{V}_n(\widetilde{w}, S)\right]^{\varphi} \left[\chi\, \widetilde{\Omega}_n^N(\widetilde{w}, S) + (1-\chi)\, \widetilde{\Omega}_n^T(\widetilde{w}, S)\right]^{1-\varphi}, \tag{12}
$$

where φ is the bargaining power of households and $\chi = \frac{N_N}{N_N + N_T}$ is the employment share of the nontradable goods sector.

[5] If instead, for example, we allow an individual household to bargain directly with firms for their workers, the household will have an incentive to accumulate additional assets to improve its outside option and increase the wage rate when bargaining. As shown in both Krusell, Mukoyama, and Şahin (2010) and Nakajima (2012), however, the effect of additional savings on the wage rate is small when the household's wealth is not close to zero, as is the case with representative households. This issue is also discussed in Choi and Ríos-Rull (2008).

In steady state, the wage rate is given by

$$w = \varphi \left[\chi \left(\Psi^f(Q^g) P F_n^N \frac{1}{\rho} \right) + (1-\chi) F_n^T + Q^e \kappa \right] - (1-\varphi) \frac{u_n}{u_{c_T}}. \tag{13}$$

We can think of the wage rate as a weighted average of the marginal product of labor and the savings on vacancy postings on the one hand, and of the worker's forfeited leisure on the other.

Equilibrium The aggregate state of the economy consists of the production capacity of the economy (capital and labor in each sector), and the net foreign asset position, $S = \{K_N, N_N, K_T, N_T, B\}$.

An equilibrium is a set of decision rules and values for the household: $\{c_N, c_T, d, \mathcal{I}, b', V\}$ as functions of its state (S, b, n), nontradable and tradable firms' decision rules and values: $\{i_N, v_N, k'_N, p_i, \Omega^N\}$, and $\{i_T, v_T, k'_T, \Omega^T\}$ as functions of their states (S, k_N, n_N) and (S, k_T, n_T), and all the aggregate variables as functions of aggregate state $S = (\theta, K_N, N_N, K_T, N_T, B)$, such that

1. Policy and value functions solve the corresponding problems.
2. Individual decisions are consistent with aggregate variables.
3. The wage rate w is determined via the Nash bargaining process (12).
4. Tradables and nontradables markets clear.

Note that in equilibrium, $\mathcal{I} = \Psi^f(Q^g)$ (i.e., consumers' demand directly translates into firms' capacity). Also note that with $\beta(1+r) = 1$, this economy may have multiple steady states with varying foreign asset positions.[6] In fact, any unexpected temporary change in any parameter will result in the economy being in a long-run position that is different from the one in which it started.

4 Mapping the Model to Data

We start by discussing some details of national accounting, describing how the variables in the model correspond to those measured in the national income and product accounts (Section 4.1). We then discuss the functional forms used and the parameters involved (Section 4.2), and finally we set the targets that the model economy has to satisfy in steady state (Section 4.3).

[6]With aggregate uncertainty, a stationary recursive equilibrium for the stochastic version requires $1 + r < \beta^{-1}$ because of precautionary savings. As we will consider an MIT shock later on, we can ignore the precautionary-saving motive and focus on the case where $\beta(1 + r) = 1$.

4.1 NIPA and Variable Definitions Issues

Real output is given by

$$Y = p^* \Psi^f(Q^g) F^N(K_N, N_N) + F^T(K_T, N_T),$$

where p^* is the steady-state price of nontradables. This amounts to measuring output using base year prices instead of current prices. Let $Y_N = p^* \Psi^f(Q^g) F^N(K_N, N_N)$ denote nontradable output and $Y_T = F^T(K_T, N_T)$ tradable output. Total consumption is $C = p^* \mathcal{I} C_N + C_T$. Total employment is $N = N_N + N_T$. Total capital is $K = K_N + K_T$. Total investment is $I = I_N + I_T$. Let υ denote the labor share in steady state. Total factor productivity or the measured Solow residual, Z, is defined as

$$Z = \frac{Y}{K^{1-\upsilon} N^{\upsilon}}.$$

4.2 Functional Forms and Parameters

Preferences We adopt GHH preferences (Greenwood, Hercowitz, and Huffman, 1988) between consumption and shopping effort, which suffices to yield that consumption per variety and the number of varieties move together, making measured TFP procyclical. The working disutility enters as an additively separable term (any consideration of Frisch elasticities is irrelevant because the work disutility matters only for wage determination). The period utility function is then given by

$$u(c_A, d, n) = \frac{1}{1-\sigma} \left(c_A - \xi \frac{d^{1+\gamma}}{1+\gamma} \right)^{1-\sigma} - \varsigma n.$$

where σ controls the risk aversion, γ determines sensitivity of consumers' disutility to additional shopping effort, and ξ and ς determine the level of disutility due to shopping and working, respectively.

The aggregator of consumption, c_A, is given by

$$c_A = \left[\omega \left(c_N \mathcal{I}_N^{\rho} \right)^{-\eta} + (1-\omega) c_T^{-\eta} \right]^{-\frac{1}{\eta}},$$

where $\frac{1}{1+\eta}$ is the elasticity of substitution between nontradable and tradable goods, ρ is the elasticity of substitution among nontradables, and ω is the nontradable home bias or home bias parameter.

Technology The production function of nontradables is

$$F^N(k, n) = z_N \, k^{\theta_N} \, n^{1-\theta_N},$$

where z_N is a parameter determining units. The production function of tradables is

$$F^T(k,n) = z_T\ k^{\theta_T^k} n^{\theta_T^n}\ L^{1-\theta_T^k-\theta_T^n} = z_T k^{\theta_T^k} n^{\theta_T^n}.$$

Land is limited, $L = 1$, hence there is decreasing returns to scale (DRS) in capital and labor.

Adjustment Costs The capital adjustment cost in the nontradable goods sector is given by

$$\phi^N(k,i) = \frac{\epsilon^N}{2}\left(\frac{i}{k} - \delta\right)^2 k,$$

where δ is the capital depreciation rate and ϵ^N determines the size of the adjustment cost. The tradable goods sector also has a capital adjustment cost

$$\phi^{T,k}(k,i) = \frac{\epsilon^{T,k}}{2}\left(\frac{i}{k} - \delta\right)^2 k.$$

In addition, the tradable sector has an employment adjustment cost,

$$\phi^{T,n}(n',n) = \frac{\epsilon^{T,n}}{2}\left(\frac{n'}{n} - 1\right)^2 n.$$

Matching The matching technologies in the labor and nontradable goods markets are

$$M^e(U,V) = \nu^e U^\mu V^{1-\mu},$$
$$M^g(D,T) = \nu^g D^\alpha T^{1-\alpha},$$

where μ and α determine the elasticity of the matching probability with respect to market tightness.

4.3 Targets and Values

The determination of the steady state requires the specification of the net foreign asset position, which we set at zero.

Targets that do not Require Solving the Model We choose a period to be 6 weeks so that the unemployment duration can be short. There are 6 such targets and associated parameters that we report in Table 1. We set risk aversion to 2 and the rate of return to 4% annually. We choose the elasticity of substitution between tradable and nontradable goods, η, to be 0.83, which is close to the values used in

TABLE 1: Targets and Associated Parameters Outside the Baseline Economy

Parameter and Associated Target	Value
Risk aversion, σ	2.0
Annual rate of return, β	$\frac{1}{\beta^8} - 1 = 4\%$
Labor matching elasticity, μ	0.50
Elasticity of substitution between tradables and nontradables, η	$\frac{1}{1+\eta} = 0.83$
Price markup ρ	1.05
Bargaining power, φ	0.52
Shopping disutility curvature, γ	1.5

the international business cycle literature.[7] We set the elasticity of the labor matching rate with respect to labor market tightness, μ, to 0.5, which lies in the middle of existing empirical estimates.[8] The price markup ρ reflects the substitutability among the nontradable goods as well as the price markup that the monopolistic firms will set. The literature provides no solid evidence on how large is this markup. Basu and Fernald (1997), using micro reasoning, claim that the implied markup is not significantly greater than 1 (1.03), whereas Christiano, Eichenbaum, and Evans (2005) estimate the price markup using macro data and obtain a value ranging from 1.01 to 1.85. Here, we have set $\rho = 1.05$. In the steady state, the bargaining power and the labor disutility cannot be separately identified, as they affect the outcomes only through the wage equation (13). Shimer (2005) sets the workers' bargaining power equal to 0.72 solely to satisfy the Hosios condition, whereas Hagedorn and Manovskii (2008) use a much smaller number: 0.05. We set the bargaining power $\varphi = 0.52$, which is in the middle of those two polar cases. This implies that the value of the unemployment (or leisure) $\frac{\varsigma}{u_{c_T}}$ to wage ratio is 0.3.

Targets and Parameters that Involve Solving the Model The second group of targets require that we solve the steady state of the model to choose values for the associated parameters. There are 12 such parameters: 2 preference parameters, $\{\omega, \xi\}$, 6 production parameters $\{z_N, z_T, \theta_N, \theta_T^k, \theta_T^n, \delta\}$, 2 search friction parameters $\{\nu^e, \nu^g\}$, and 2 labor market parameters $\{\lambda, \kappa\}$. Table 2 lists the steady-state targets and associated parameters for the baseline economy.[9] Many of the targets in Table 2 have economic meaning while others are just the determinants of units. Accordingly, the table displays the unit targets separately.

In terms of the targets of the job flows, we set the steady-state employment rate to 90%, which is the

[7] The estimates of the elasticity of substitution can be much higher in the trade literature, as recently discussed in Feenstra, Luck, Obstfeld, and Russ (2018).

[8] Merz (1995) considers the elasticity to be 0.4, Shimer (2005) 0.72, and Hall (2005) 0.24.

[9] The term "associated" refers to the attempt to link targets and moments according to some intuitive link between them. Mathematically, they are all interdependent.

TABLE 2: Steady-State Targets and Associated Parameters

Target	Value	Parameter	Value
Share of tradables, $\frac{F_T^*}{Y^*}$	25%	ω	0.95
Employment rate, E^*	90%	ν^e	0.16
Monthly job separation rate	1.15%	λ	0.017
Occupancy rate, $\frac{C_N^*}{F_N^*}$	81%	ν^g	0.81
Capital to output ratio, $\frac{K^*}{Y^*}$	3	δ	0.007
Labor share in nontradables	0.6	θ_N	0.67
Labor share in tradables	0.6	θ_T^N	0.64
Equal role of capital and land in tradables	$2\theta_T^K + \theta_T^N = 1$	θ_T^K	0.18
Units Targets			
Output, Y^*	1	z_N	0.45
Relative price of nontradables, p^*	1	z_T	0.50
Market tightness in labor markets, $\frac{U^*}{V^*}$	1	κ	0.29
Market tightness in goods markets, D^*	1	ξ	0.03

average employment rates of the southern European countries (Greece, Italy, Portugal, Spain) between 1995 and 2008. We set the monthly job separation rate to 1.15%, the average of these countries based on the estimation in Hobijn and Şahin (2009).[10] We target a capacity utilization or occupancy rate of 81%, which is the average of the official data series (Corrado and Mattey (1997)), and a labor share of 60% in both the nontradable sector and tradable goods sector. We target the tradable goods to output ratio (share of tradables) to be 25%. Following the literature, the tradable goods sector typically includes agriculture, mining, and manufacturing industries. We choose a contribution of land to output of tradables to be a size equal to that of capital, which determines the size of the decreasing returns of the sector. We also target an annual capital-output ratio of 3.

We normalize output, the relative price of nontradables, and market tightness in both labor and goods markets to 1. The parameters more closely related to these unit targets are the definition of units in the production function z_T and z_N as well as the vacancy cost κ, and the parameter that transforms search units into utils, ξ.

[10] In Hobijn and Şahin (2009), job finding rates vary a lot across the Southern European countries, while the job separation rates display a much smaller dispersion.

5 A Recession Induced by a Shock to the Discount Factor

To generate a reduction in consumption which is the trigger of the recession, we consider the simplest mechanism we can think of, a one-time unexpected shock to the discount factor, that gradually goes back to its original value. We first explore the baseline economy (Section 5.1) which requires a previous detour into the specification of the parameters that govern non steady-state behavior. We then turn to study the role of each of the three frictions that we have introduced by turning them off one by one. We first look at the role of goods market frictions (Section 5.2), then move to adjustment costs in production (Section 5.3) and finish with labor market frictions (Section 5.4). The section ends with a standard analysis of robustness, by changing some of our calibration targets in Section 5.5.

TABLE 3: Dynamically Calibrated Parameters of the Baseline Economy

Target	Value	Parameter	Value
Response of nontradable investment	$\frac{\Delta I^N + \Delta I^T}{\Delta Y} = 4$	ϵ^N	55.17
Response of tradable output	$\frac{\Delta Y^T}{\Delta Y} = -4$	$\epsilon^{T,n}$	50.70
Symmetry of tradable adjustment costs	$\epsilon^{T,k} = \epsilon^{T,n}$	$\epsilon^{T,k}$	30.70
Response of labor to output	$\frac{\Delta N}{\Delta Y} = .5$	α	0.46

Dynamic Parameters and Aggregate Shocks In Section 4 we left out the discussion of the targets associated to the parameters that have no steady-state implications. We turn to specify them now as these targets are related to the dynamic response of the economy to shocks. They are shown in Table 3. To analyze the effect of the aggregate shocks we use an MIT shock starting from the steady state that is revealed to agents in the economy at the beginning of period 0. The shock makes the discount period rate β in each period t going forward changes to become $\beta(1 + \tau_t)$, where τ_t gradually returns to zero following $\tau_t = \vartheta\tau_{t-1}$. The particular shock that we look at has a persistence $\vartheta = 0.95$ and we choose the initial τ_0 so that real output shrinks by 1%.

The additional parameters are chosen to impose certain properties of the dynamic response of the economy to this shock. In particular, we choose the capital adjustment cost in the nontradable goods sector ϵ^N so that the immediate response of investment is four times as large as the response of total output at its lowest point. That is, we want a 1% decrease in total output to be associated with a 4% decrease in investment. We want output in the tradable sector to expand by 4% when total output Y drops by 1% (which may even be too large a target), and we want adjustments in labor and capital of tradables to be symmetric. A higher α implies a larger volatility of capacity in the goods market, as well as a larger role played by consumers' demand in shaping TFP. We choose α so that when total output declines by 1%, the employment rate shrinks by 0.5%. In the end, the required increase of τ_0 is 1.6%.

5.1 Performance of the Baseline Economy

A household that suffers a positive shock to its patience wants to shift consumption and leisure towards the future and reduces its consumption of both tradables and nontradables. Its willingness to work harder translates into a wage reduction but not into an increase in labor unless firms pose more job vacancies. Less tradable consumption translates directly into more net exports, a form of saving. Given our assumptions on preferences, households implement a reduction of nontradable consumption by reducing both the number of consumption varieties and the quantity of each variety. This in turn reduces productivity (fewer locations are occupied) and the prices of nontradables and, consequently, output and profits of nontradable firms for a few periods. The tradable sector expands because of the reduction in wages, but only in a limited way because of the decreasing returns to scale of this sector and of the adjustment costs that slow its expansion.

FIGURE 2: Impulse Responses in the Baseline Economy

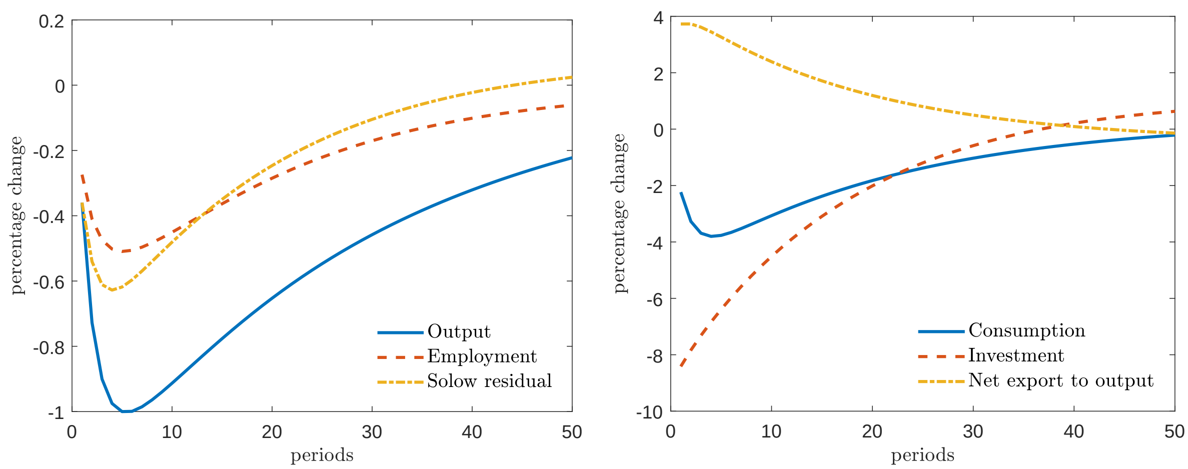


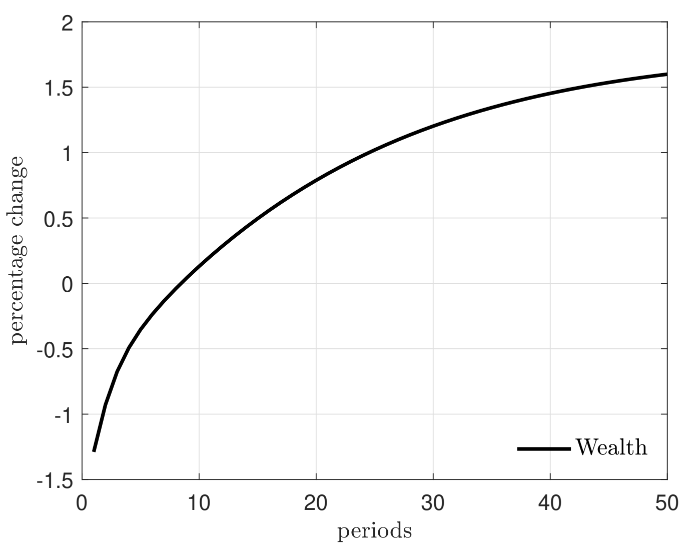
Figure 2 displays the impulse responses of the main macroeconomic variables to the shock in the baseline economy. First, look at the supply side. Recall that the initial shock τ_0 and the dynamic parameters are set such that output drops by 1% and employment drops by 0.5%. The model endogenously generates a reduction of measured TFP of over 0.6%. This is due to the fact that when households cut their nontradable expenditures, they do so by decreasing both the number of consumption varietes and the quantity consumed of each variety. A lower number of varieties implies that more locations fail to produce sales and hence output, which results in a loss in measured TFP. The reduction of output, TFP, and employment extends the intuition in the simple model in Section 2 to a dynamic setting with endogenous production.

Turn now to the demand side. Both the reductions in tradable and nontradable consumption contribute to the decrease of aggregate consumption, though the reduction in nontradable goods is smaller because the relative price of nontradables falls (a form of internal devaluation) making those goods relatively more attractive. Adjustments costs are set so that the decrease in investment of nontradables falls four times that of nontradable output, which is experimenting an already large fall. We also limited the expansion of tradable output. All this results in an overall reduction of investment of 8% and in an increase in net exports to output of 4%. The adjustment costs also make the recession long lived, even though the economy will converge eventually to a situation with higher output. The accumulation of savings in foreign assets implies that in the long run the economy will have a current account deficit to consume its proceeds and nontradables will expand.

Note the heterogeneous responses in the tradable and the nontradable sectors. Firms in tradable sector face a perfect elastic demand and benefit from cheaper labor costs. They expand both employment and investment. In contrast, firms in the nontradable sector suffer from a depressed demand which results in both a lower price level and a lower probability of selling their products, and they scale down the inputs of production. As the effects on the nontradable sector dominates those on the tradable sector, the whole economy is in a recession.

An interesting property of the economy is that a paradox of thrift arises. Wealth, which is the sum of the foreign bonds and the present discounted sum of profits, $W_t = (1 + r)b_t + \sum_{k=t}^{\infty} \frac{\pi_{N,k}+\pi_{T,k}}{(1+r)^{k-t}}$. initially shrinks as shown in Figure 3. It takes over a year to recover its initial level, and eventually increases 1.7%.

FIGURE 3: Response of Wealth



To summarize, in the baseline economy, an increase in savings generates a long-lasting recession with reductions of both employment and productivity on the production side. With respect to output composition, consumption and investment shrink while there is an increase in net exports. As stated before, all of these features are consistent with the experience in Southern Europe (see Figure 1).

5.2 Role of Goods Market Frictions

We now consider the quantitative importance of the search friction in the nontradable sector. For this we pose an economy like the baseline except that there are no search frictions in the goods market, and therefore, consumers use all consumption varieties and the economy operates at full capacity.

FIGURE 4: Impulse Responses in the Economy without Goods Market Friction

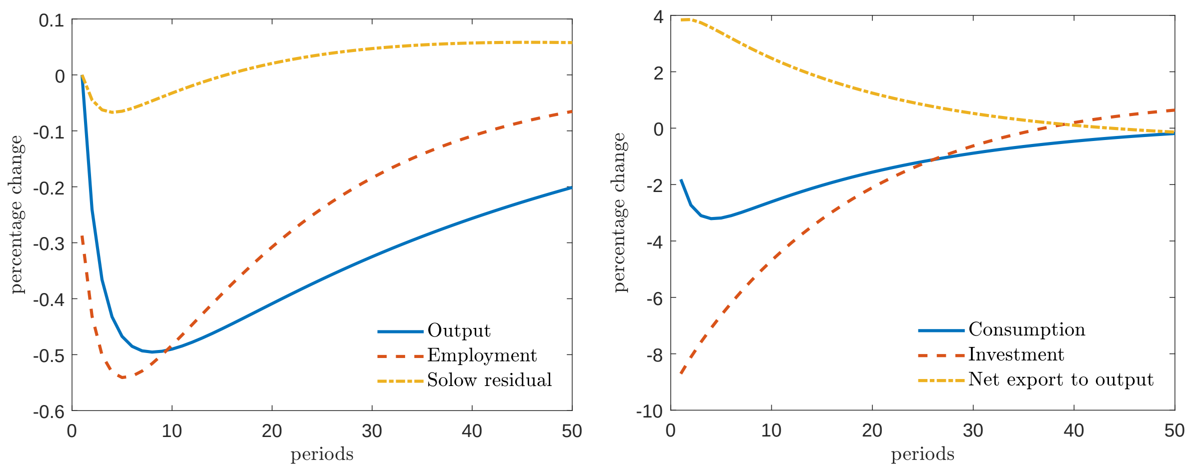


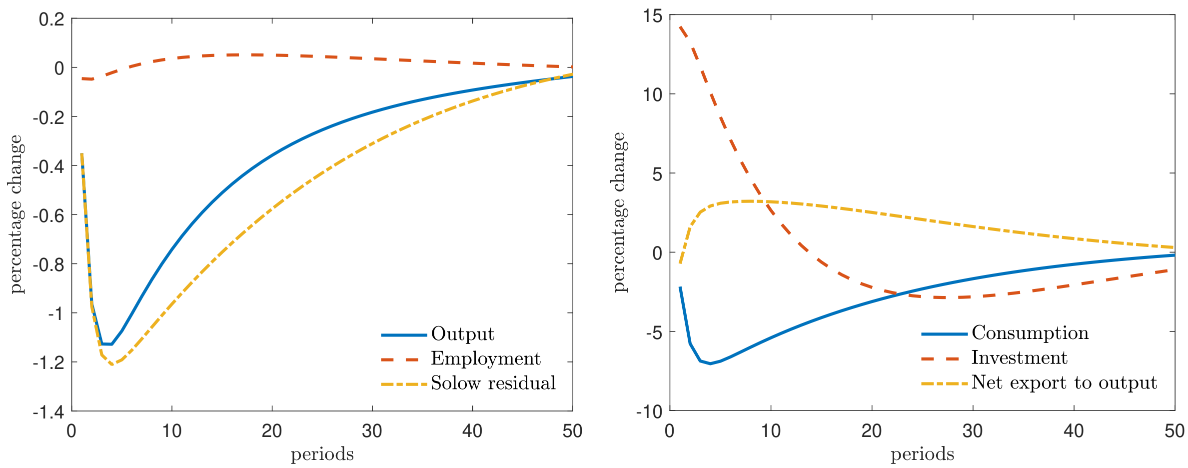
Figure 4 shows the responses of main aggregate variables in this alternative economy. The bottom line is that the economy still experiences a recession, but of a much smaller magnitude. Output shrinks by 0.5% instead of 1%, which is due to the missing reduction of TFP (there is small change of measured TFP due to the reallocation of production inputs across sectors and to the decreasing returns to scale in the tradable sector). In addition, without goods market frictions, nontradable prices have to drop even more in order to clear the goods market (3.5% more than the baseline case), which puts further downward pressure on firms' profit and hiring incentives.

5.3 Role of Adjustment Costs

We now change the baseline economy by eliminating adjustment costs (by setting then almost to $\epsilon^{T,k} = \epsilon^{T,n} \approx 0$). In this economy, the higher desire to save can be implemented by investing more. As a result, investment skyrockets rather than fall. The economy experiences a reduction of output, but not of employment: the higher installed capital makes employment more attractive despite the reduction of

TFP associated to the reduction in consumption of nontradables and in the expansion of tradables with their decreasing returns to scale. There is a mild increase in net exports, especially after a few periods, when the newly installed capital and the higher employment in the tradable sector has already taken place. These features are displayed in Figure 5.

FIGURE 5: Impulse Responses in the Economy with Low Adjustment Costs

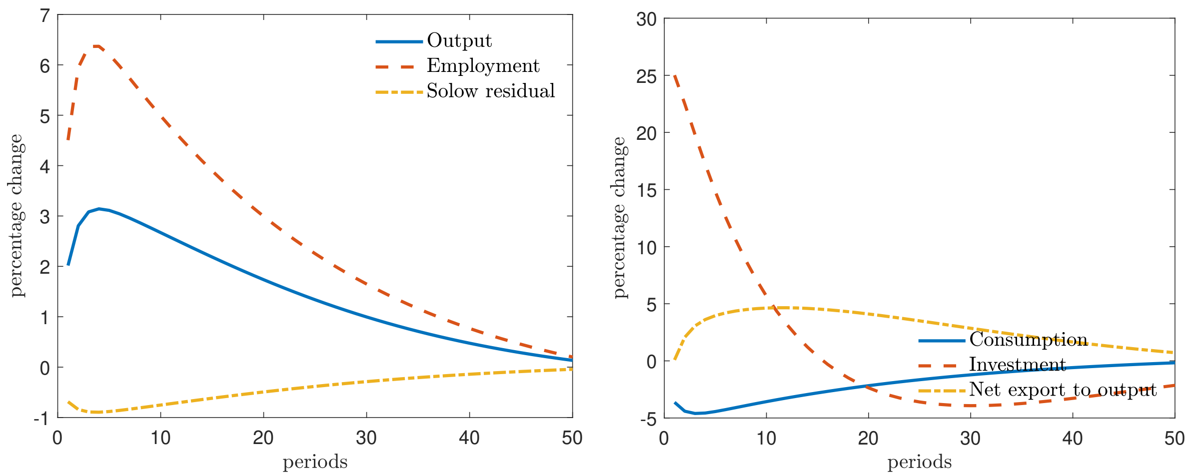


A counter-intuitive pattern of this economy is that total output drops more than in the baseline case. The reason is that the nontradable sector experiences an even larger decline than in the baseline which dominates the additional expansion of the tradable sector. When firms in the tradable sector hire more workers, the labor market becomes tighter and it is even more costly for nontradable firms to hire. This general equilibrium effect makes nontradable firms reduce their employment, leaving total employment roughly constant. However, the reduction of employment in the nontradable sector has a larger impact on total output than the expansion of employment in the tradable sector due to the decreasing returns to scale of tradables. By the same logic, if the matching elasticity in the labor market were smaller, firms would face higher hiring costs, resulting in a larger drop of output. We show that this is indeed the case in Section 5.5. Overall, the performance of this economy is not what we think of as a recession even if output falls.

5.4 Role of Labor Market Frictions

In our economy, a shock to patience induces households to reduce consumption and to increase labor today relative to tomorrow. If households were able to choose how much to work, the economy would yield an increase in labor, thereby generating an expansion, not a recession. This occurs because households are willing to accept a lower wage to delay gratification.[11] Therefore, in a version of our economy without search frictions in the labor market, it is a reduction of patience what generates a recession with lower work and higher wages.

FIGURE 6: Impulse Responses in the Economy without Labor Market Friction



To implement an economy without labor market frictions, we modify the utility function to

$$u(c_A, d, n) = \frac{1}{1-\sigma}\left(c_A - \xi d\right)^{1-\sigma} - \frac{n^{1+\gamma}}{1+\gamma},$$

where we set the inverse of Frisch elasticity to be 1.5. The amount of labor n can now be chosen by households, and the wage rate adjusts to clear the labor market.

Figure 6 displays the performance of this economy. As stated, employment increases and so does output even though there is a reduction of measured TFP coming from the reduction of nontradable consumption. Such large increase in work effort is enough to induce an increase in investment, overcoming the adjustment costs, which results in a delayed increase in exports.

In this case, a desire to save leads to higher saving, temporarily lower consumption, higher employment, and an expansion. This is a robust prediction of standard real business cycle model, which make it difficult to engineer a demand induced recession from reductions in consumption. We conclude that sizable labor market frictions are a necessary ingredient of recessions that come from shocks that induce workers to consume less and work more.

[11]The traditional way to avoid this problem is to assume wage or price stickiness as in most New Keynesian models. Recent practice includes Midrigan and Philippon (2011), Guerrieri and Lorenzoni (2017), Schmitt-Grohe and Uribe (2011), and Heathcote and Perri (2012).

5.5 Robustness

We now turn to examine the sensitivity of our results to alternative specifications of the targets. We vary the elasticity of substitution between tradable and nontradable goods, η, the labor matching elasticity, μ, the bargaining power φ, and the price markup (the elasticity of substitution among nontradable goods), ρ. The change of any of these specifications require a complete recalibration of the model to maintain the same targets in Table 2. We keep the dynamic parameters the same as in Table 3. The relationship between the magnitude of the output drop with the variations of these parameters is summarized in Figure 7.

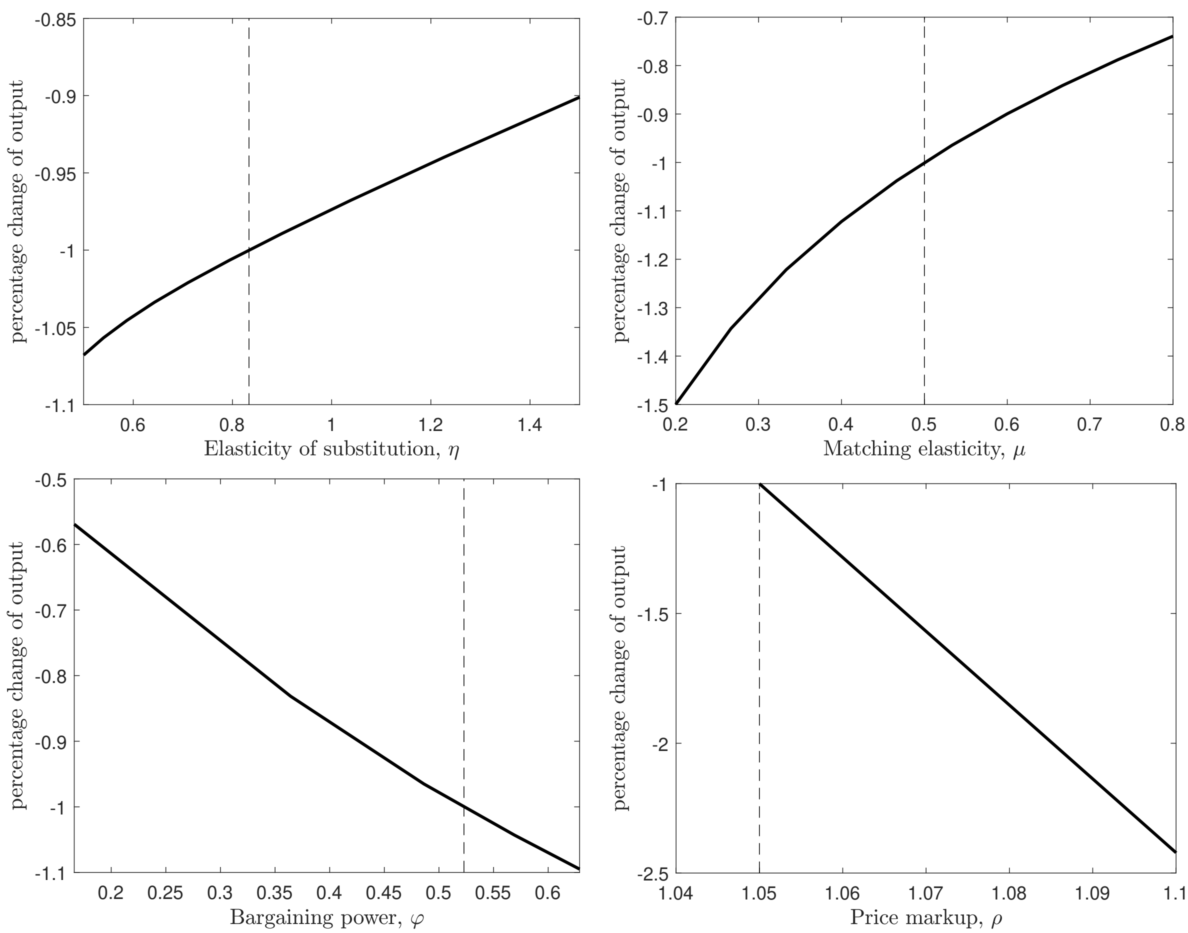
A higher elasticity of substitution between nontradables and tradables, η, allows households to reduce a lot their consumption of tradables without reducing nontradables too much. Consequently, nontradable firms do not need to cut their employment and investment as much as before, and the reduction of measured TFP is also limited, which makes recessions less severe.

A higher matching elasticity, μ, leads to a less frictional labor market. Hiring a new worker becomes cheaper, and the total reallocation costs are smaller as well. As a result, it is easier for the tradable sector to expand its employment size, leaving the total output drop smaller.

In the labor market search literature, most studies focus on the effect of productivity shocks on labor market volatility (Shimer, 2005; Hagedorn and Manovskii, 2008). A larger bargaining power for workers implies large wage volatility and low employment volatility. However, this argument cannot be carried over to the current environment. In our environment, the recession is triggered by changes in households' willingness to enjoy consumption and leisure today versus tomorrow. The wage rate is more responsive with a smaller φ. Intuitively, when workers' bargaining power is small, it is easier for firms to demand a wage cut, which in turn reduces the loss of employment.

The elasticity of substitution between nontradable goods is $\frac{\rho}{\rho-1}$. A higher ρ lowers the substitutability between nontradable goods and increases the elasticity of the number of varieties per household, $\mathcal{I}$, with respect to consumption per variety, c_N. In other words, with the same reduction of the quantity c_N, an economy with higher ρ tends to experience a larger decline in the number of varieties, $\mathcal{I}$ and, therefore, a larger decline of measured TFP. As can be seen from the lower right panel of Figure 7, the change of output is relatively sensitive to this parameter. In this regard, recall that our target choice for the baseline economy was on the low end of the literature, which implies that our estimate of the drop in output that results from the shock is a conservative estimate.

Figure 7: Robustness



Notes: The vertical dashed lines are corresponding to the values used in the baseline calibration.

6 Other Types of Shocks

The shock to the discount rate is a reduced-form modeling device to induce households to increase their savings. We now consider two alternative shocks that can be more directly connected with observables, though the underlying logic that causes the recession is similar to that in the baseline, a shock that destroys household wealth (Section 6.1) and a shock that difficults consumption smoothing that we think of as a form of financial shock (Section 6.2).

6.1 Wealth Shock

We first engineer a recession by a sudden reduction in the net foreign asset position. We set the size of the reduction to be 10% of households' initial wealth level where households go from a zero net foreign asset position to a negative asset position equal to about one (year of) GDP. This exercise explores the implication that when households become impoverished, they lower their consumption, which brings about a permanent drop in output and in the Solow residual. We think (perhaps controversially) that such a wealth shock captures some key elements of the mechanism that triggered the recession in southern Europe—the size of the public debt was larger and the banking system was in worse shape than previously thought, and the generosity of the northern neighbors became greatly reduced.

FIGURE 8: Impulse Responses to Weath Shock

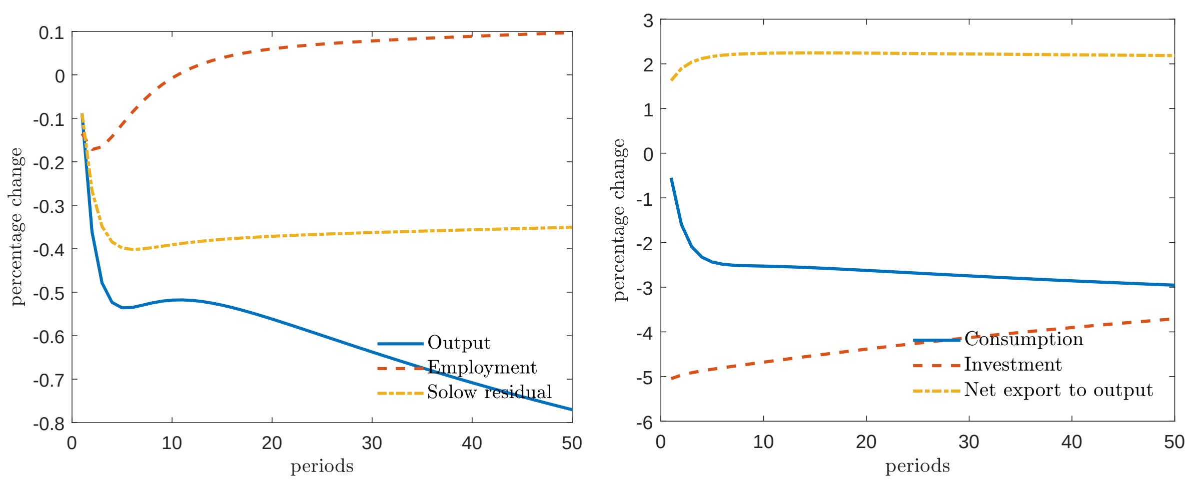


Figure 8 covers the transition dynamics after the shock. The changes are now permanent: output, the Solow residual, and consumption transit eventually to a lower level, but not employment. The impoverishment requires the economy to reallocate resources into the tradable goods sector, resulting in a permanent expansion of tradable goods production and net exports. There is also a permanent decline in wages, which encourages a permanent increase in employment, but only after a decline in the short run arising from the adjustment costs.

Shocks to the discount factor β and to wealth both induce a recession in the short run. However, the paths of recovery are quite different. After a discount factor shock, consumption rebounds and eventually surpasses its original level. Other aggregate variables follow a similar pattern. With a shock to wealth, however, output, the Solow residual, and aggregate consumption transit to a quite different and lower steady state.

Southern European economies have stagnated for a relatively long time. Through the lens of our model economy, after a shock to wealth, it is difficult for households to rebuild their balance sheet: the depressed demand reduces households' income because of the general equilibrium feedback effects, which slow down the accumulation of wealth. The interaction between households' persistently strong saving incentive and its adverse effects on domestic production can lead to a slow recovery or to a permanently worse steady state.

6.2 Financial Frictions

We now extend our model to allow a limited form of within the household heterogeneity that is capable of accommodating shocks to the financial system that trigger changes in savings. We assume that there are financial costs to transfer resources from the employed household members to the unemployed household members ensuring that they have different consumption levels. These costs are lower when wealth is higher because the transfers of the employed to the unemployed are smaller. Let ψ be a financial cost per unit of transfer to an unemployed worker. A relatively permanent increase of ψ makes it more expensive to insure unemployed workers, which encourages the household to increase savings. Shocks to ψ have effects that are similar to those of shocks to the discount factor.

Because the the two groups of agents consume different amounts, they assess the trade-off between search and consumption differently. Specifically, the unemployed care relatively more than the employed for lower prices relative to search intensity, which generates a rationale for firms to try to price discriminate. Consequently, firms set themselves up in two different goods markets with different prices, different market tightness, and different amounts sold. In other words, goods markets are segmented. Household member can choose which goods market to go to. Firms will gear a fraction of their locations, x^u, to cater to unemployed workers and the rest locations, x^e, to employed workers. The former will face higher market tightness and lower prices, but, as it turns out, not lower quantities of each good. This result is consistent with the evidence provided by Aguiar, Hurst, and Karabarbounis (2013) and Kaplan and Menzio (2013). The nontradable firms' problem is

$$\Omega^N(S,k,n) = \max \; x^e p^e \Psi^f(Q^{g,e}) C^e(p^e,S) + x^u p^u \Psi^f(Q^{g,u}) C^u(p^u,S) - wn - i - \kappa v + \frac{\Omega^N(S',k',n')}{1+r}$$

subject to

$$
\begin{aligned}
F^N(k,n) &\geq x^e C^e(p^e,S) + x^u C^u(p^u,S),\\
x^e + x^u &\leq 1,\\
k' &= (1-\delta)k + i - \phi^N(k,i),\\
n' &= (1-\lambda)n + \Phi^f[Q^e(S)]v,\\
S' &= G(S).
\end{aligned}
$$

The equilibrium allocation requires firms to be indifferent between setting a location to cater for the employed or for the unemployed, and consequently, they set their prices such that the amount of goods sold at each location is identical

$$p^e \Psi^f(Q^{g,e}) = p^u \Psi^f(Q^{g,u}) = \zeta, \tag{14}$$

$$c_N^e = c_N^u, \tag{15}$$

where the market tightness in equilibrium equals

$$Q^{g,e} = \frac{x^e}{nD^e}, \qquad Q^{g,u} = \frac{x^u}{(1-n)D^u}.$$

Satisfying (14) requires $p^e > p^u$ and $\Psi^f(Q^{g,e}) < \Psi^f(Q^{g,u})$. The employed shop at locations with smaller tightness, but they pay a higher price; the unemployed pay a lower price but search harder.

Due to the existence of within-period financial frictions, households now need to decide the consumption plans for their employed and unemployed members separately. Their problem becomes

$$V(S,b,n) = \max\ n\, u(c_A^e, d^e, 1) + (1-n)\, u(c_A^u, d^u, 0) + \beta\, \mathbb{E}[V(S',b',n')] \qquad \text{s.t.}$$

$$
\begin{aligned}
n(p^e \mathcal{I}^e c_N^e + c_T^e) + (1-n)(p^u \mathcal{I}^u c_N^u + c_T^u) &= (1+r)b + wn + \pi_N + \pi_T - \psi(1-n)\mathcal{T} - b',\\
\mathcal{T} &= p^u \mathcal{I}^u c_N^u + c_T^u - [(1+r)b + \pi_N + \pi_T],\\
\mathcal{I}^e &= \Psi^d(Q^{g,e})\, d^e,\\
\mathcal{I}_N^u &= \Psi^d(Q^{g,u})\, d^u,\\
\zeta &= p^e \Psi^f(Q^{g,e}) = p^u \Psi^f(Q^{g,u}),\\
n' &= (1-\lambda)n + \Phi^w(Q^e)(1-n),\\
S' &= G(S).
\end{aligned}
$$

In the budget constraint, the transfer to an unemployed worker is $\mathcal{T}$, which measures the difference between the unemployed consumption and per agent financial assets. The total financial costs of this transfer are $\psi(1-n)\mathcal{T}$, where ψ parameterizes the degree of financial frictions. When households accumulates more savings, the financial costs to achieve the perfect risk sharing are smaller.

The intra-temporal first-order condition relates the consumption for employed and unemployed is

$$u_{c_T^u} = (1+\psi)u_{c_T^e}.$$

The financial cost ψ serves as a wedge between the marginal utility of consumption of the two groups. The corresponding Euler condition is

$$u_{c_T^e} = \beta(1+r)\mathbb{E}\left[u'_{c_T^e}(1+\psi'(1-n'))\right].$$

Ceteris paribus, an increase of ψ is akin to an increase of the discount rate.

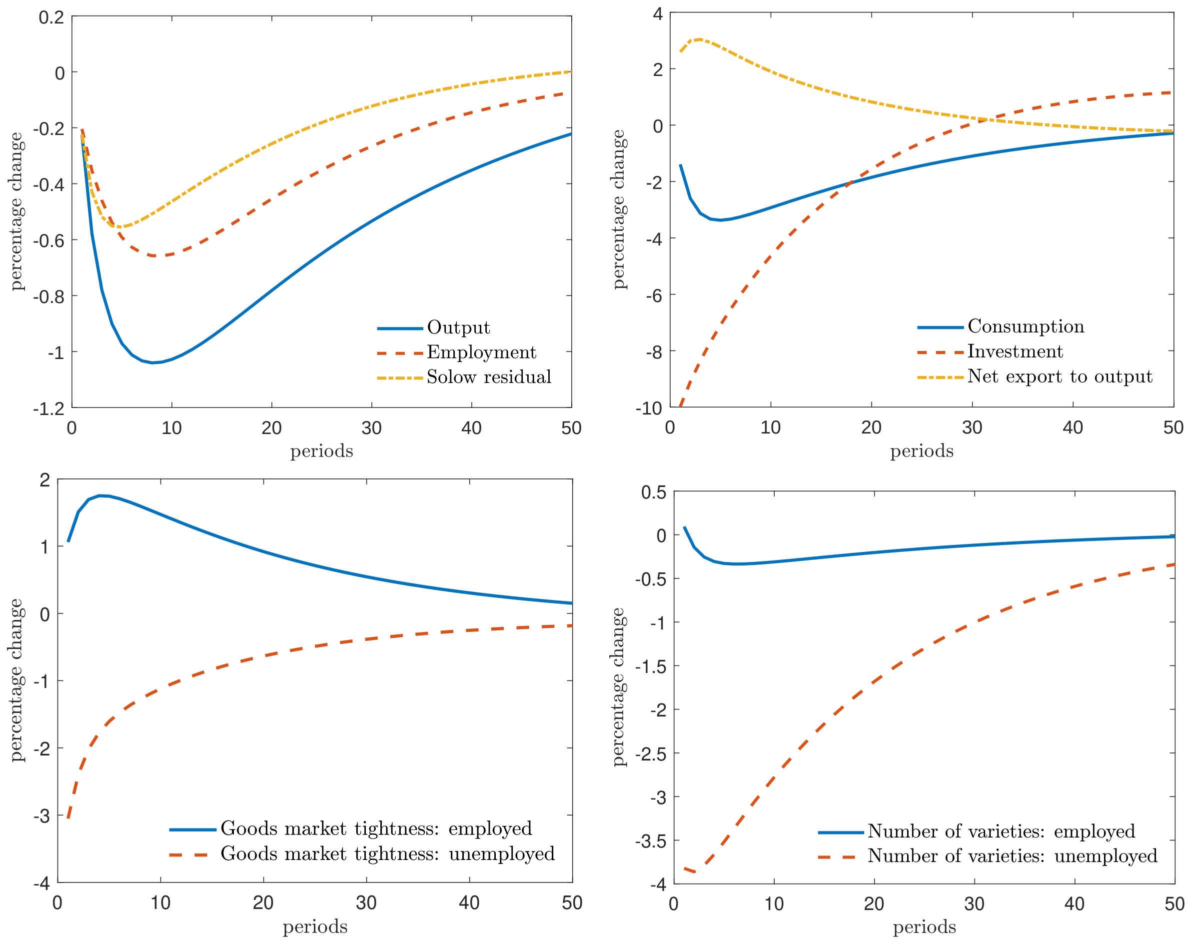
In the initial steady state, we set $\psi = 0$. In this case, perfect risk sharing is achieved and the economy is the same as that in the baseline economy where employed and unemployed workers share the same consumption. At period 0, ψ increases to 10% unexpectedly, and gradually returns to zero following $\psi_t = \vartheta\psi_{t-1}$, where the persistence is set to be the same as that of the discount factor shock, $\vartheta = 0.95$.

Figure 9 displays the responses of various variables to the increased financial costs. Both the magnitude and the dynamic pattern of the main aggregate variables are similar to their responses to the discount factor shock showing that this shock is indeed a good approximation to the type of financial shocks that are talked about in the popular press.

What is unique in this economy is the heterogeneous responses of the employed and unemployed workers. After the shock to ψ, agents reduce both the amount of consumption of each variety and the number of varieties. The unemployed workers care less about exerting search effort, and it is optimal for them to shop in markets with lower probability of finding a location. The bottom left panel shows the changes in the goods markets tightness. The market tightness is increasing for the employed but decreasing for the unemployed. This is due to both that more locations are allocated to the market for employed, and that the unemployed exert more search effort.

Even though market tightness moves in opposite directions, both groups reduce the number of varieties. The unemployed reduce the number of varieties in a much more dramatic way as their consumption expenditures become very costly when the financial costs surge.

Figure 9: Impusel Response to Financial Friction Shock



7 Conclusion

In this paper, we have generated demand-induced recessions in a neoclassical growth model, that is, a model that is not subject to arbitrary restrictions in the functioning of goods prices as New Keynesian models do. The two necessary ingredients are adjustment costs that make it difficult for the economy to expand the tradable sector by reallocating factors of production from nontradables to tradables, and some form of noncompetitive labor markets (Mortensen-Pissarides labor search frictions and wage setting via Nash bargaining being is enough). In addition, our model poses frictions in goods markets, where increases in consumers' search efforts enable the economy to operate at a higher capacity (following recent work by Huo and Ríos-Rull (2014)). Consequently, reductions in household consumption reduce measured TFP. This feature is quantitatively important: its presence doubles the effects of shocks. The recessions that we induce display the paradox of thrift in the sense that increases in household savings reduce wealth at the start of the recession, and it takes a few quarters before it recovers its initial level.

Finally, an extension of our model features financial frictions that, when subject to shocks, generate fluctuations like those derived from shocks to patience, even in the context of a representative agent model. We think that in many ways, the type of recession we have posed resembles what is currently happening in southern Europe.

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