Paradox of Thrift Recessions*

Zhen Huo
University of Minnesota
Federal Reserve Bank of Minneapolis

José-Víctor Ríos-Rull
University of Minnesota
Federal Reserve Bank of Minneapolis
CAERP, CEPR, NBER

September 2013

Abstract

We build a variation of the neoclassical growth model in which both wealth shocks (in the sense of wealth destruction) and financial shocks to households generate recessions. The model features three mild departures from the standard model: (1) adjustment costs make it difficult to expand the tradable goods sector by reallocating factors of production from nontradables to tradables; (2) there is a mild form of labor market frictions (Nash bargaining wage setting with Mortensen-Pissarides labor markets); (3) goods markets for nontradables require active search from households wherein increases in consumption expenditures increase measured productivity. 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

*Ríos-Rull thanks the National Science Foundation for Grant SES-1156228. We are thankful to Mark Aguiar and Francois Gourio for discussing this paper, and for discussions with George Alessandria, Yan Bai, Christopher Carroll, Oleg Itskhoki, Nir Jaimovich, Greg Kaplan, Patrick Kehoe, Pete Klenow, and Kjetil Storesletten, as well as the comments of Joan Gieseke and the attendants at the many seminars where this paper was presented. The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

1 Introduction

We develop a model in which recessions are triggered by households' desire to save more. Although mapped to a standard modern economy, our model features three ingredients that represent a mild departure from standard neoclassical growth theory:

1. Adjustment costs make it difficult to reallocate resources from the production of nontradable goods to the production of tradables, thereby preventing a rapid reallocation of production from consumption to investment or exportation.

2. The labor market is not competitive; instead, it is subject to search frictions à la Mortensen-Pissarides with Nash bargaining over the wage.

3. Goods markets for nontradables require active search from households. We extend Bai, Ríos-Rull, and Storesletten (2011) to an environment in which reductions in consumption generate reductions in productivity. This happens because households reduce consumption by reducing the number of consumption varieties as well as the quantity spent on each variety, and the reduction in the number of consumption varieties reduces the economy's capacity utilization rate.

We show that, contrary to standard growth models, households' desire to increase savings is a catalyst for a recession, not an expansion. Moreover, the onset of the recession reduces firms' value enough to reduce total household wealth despite households' increased savings. In this sense, our economy presents a *paradox of thrift*. Wealth recovers its initial value only after a few months. Although the novel mechanism that we model here—that households choose both the number of consumption varieties and the quantity of each variety that they consume—is not necessary for an increase in household savings or a negative wealth shock to spark a recession, its effects reduce by 2.3 times the size of the shocks needed for a given size of output contraction, which we deem to be large. Although our model economy does not include price rigidities, we document the extent to which such rigidities make recessions easier to obtain (via smaller shocks).

Our baseline economy uses shocks to patience to trigger households' increased desire to save for expository reasons.[1] We also study a recession that is generated by a sudden reduction in the wealth of households that triggers a reduction of consumption and hence a recession. Such a

[1] Eggertsson (2011), Christiano, Eichenbaum, and Rebelo (2011), Correia, Farhi, Nicolini, and Teles (2013), Rendahl (2012), Eggertsson and Krugman (2012), and Schmitt-Grohe and Uribe (2012) all use shocks to the discount factor as the mechanism to trigger increases in savings. In 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 rigid prices or wages.

reduction in wealth could be linked to the experience of southern Europe (due perhaps to larger public debts than previously believed or to reductions in the generosity of their northern neighbors). We also provide a version of our model in which the recession is again generated via an increase in household's desire to save, only this time, instead of shocks to patience, shocks to financial intermediation—specifically, shocks to the costs to provide insurance to the unemployed—are responsible for sparking the recession. Our implementation of financial shocks has the advantage of being implementable within the representative agent framework.

FIGURE 1
Aggregate Economic Variables in Southern European Countries

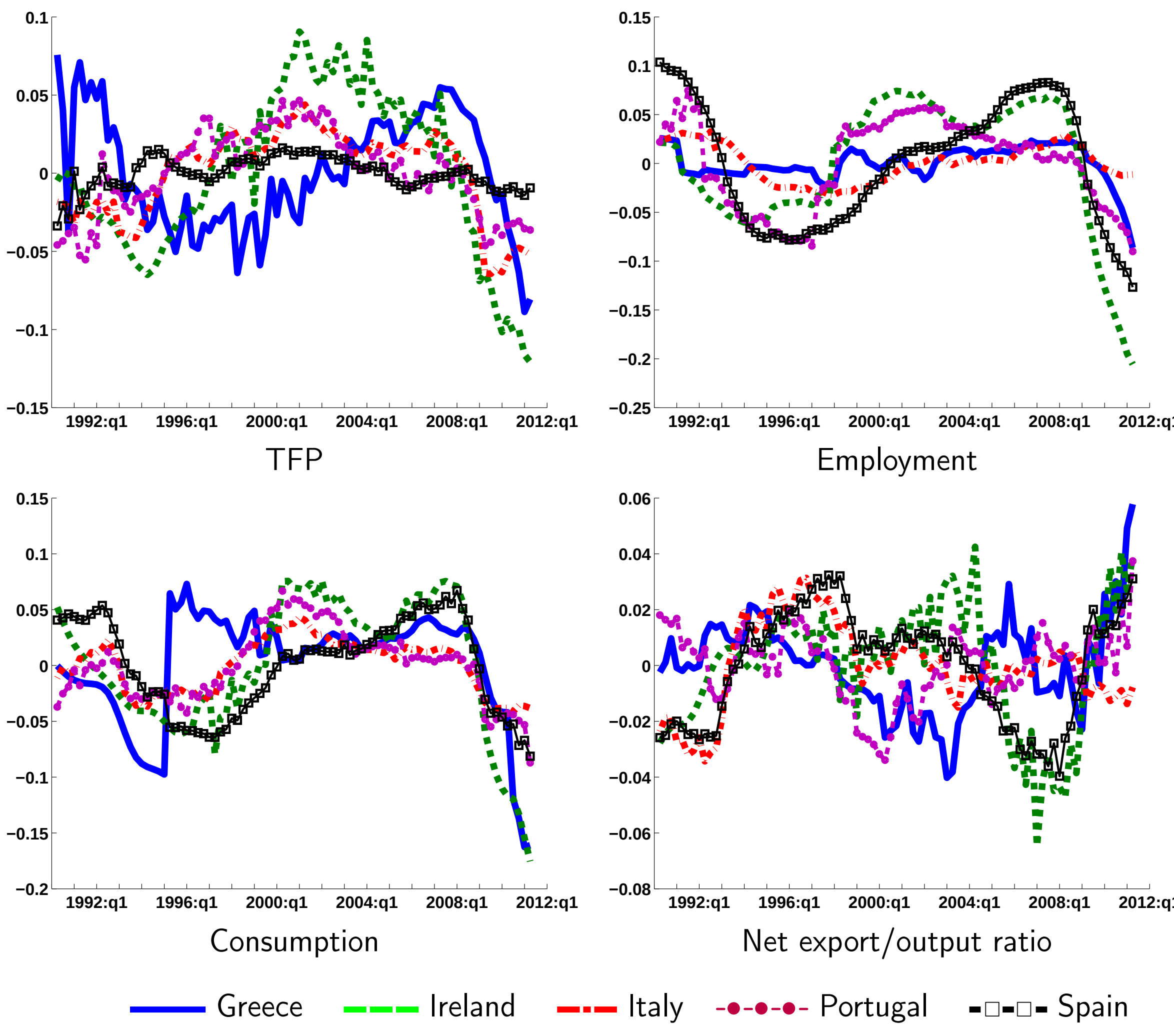


Figure 1 displays the main aggregate variables in southern European countries. The current recession starting from 2008 features a big drop in measured total factor productivity (TFP), a fairly large decline in employment and consumption, and a rise in net exports. The predictions of our model are consistent with what is currently happening in southern Europe.

In order for a recession to be generated via households' increased desire to save, the environment has to be such that saving for the future through both investment and exports is difficult. In our economy, adjustment costs prevent a rapid reallocation of production from consumption to investment or exporting goods. Kehoe and Ruhl (2009) argue that without labor adjustment costs, too much shifting of resources into the tradable sector occurs, whereas Alessandria, Pratap, and Yue (2013) find that frictions in exports are necessary to match the gradual increase in exports that follows a devaluation.[2]

Whatever reason that induces a household to save more—because its preferences have shifted toward the future, because it is poorer than before, or because a financial shock increases its desired wealth to earnings ratio—it would also make the household to want to work harder. The typical strategy to avoid this response is to prevent the labor market from clearing via some form of wage stickiness, so that labor demand will determine employment (Schmitt-Grohe and Uribe (2011), Midrigan and Philippon (2011), and Farhi and Werning (2012)). We follow a different approach, breaking down the static first-order condition of the household by posing standard labor market search frictions à la Mortensen–Pissarides. Clearly, wage rigidity makes recessions more likely, as we document later on, but even the mild deviation from competitive labor markets implied by the search friction is sufficient to generate recessions.

Our theoretical contribution is an extension to the work of Bai, Ríos-Rull, and Storesletten (2011), who model goods markets as having frictions where more intense search on the part of households translates into productivity gains as the economy operates at a higher capacity without more intense use of productive inputs. In their paper, search effort essentially behaves as a substitute for labor, and hence a desire to work harder or to save more would imply more search and increased productivity—hardly the trademark of recessions. In our paper, we provide a different channel through which search frictions affect productivity, ensuring that search and consumption are complements. Preferences are such that households have a taste for variety à la Dixit-Stiglitz, but each variety must be found, which requires search. In our model, when consumers want to increase their consumption, they do so by increasing the number of consumption varieties and consuming more of each variety. Hence, search effort is not a substitute for the resources spent when consuming

[2] Extreme versions of this assumption can be found in Midrigan and Philippon (2011), who assume that labor is not perfectly substitutable among different sectors, and the work of Mendoza (2001), Schmitt-Grohe and Uribe (2011), and Farhi and Werning (2012), where tradable goods are given exogenously.

but rather a complement to them. In this manner, an increased desire to save reduces productivity.

The predictions of our model for the number of varieties are consistent with the empirical findings of Jackson (1984) and especially Li (2013): consumers increase consumption by increasing both the number varieties and the quantity of each variety. In fact, Li (2013) 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 for are only for time series. However, in the 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.

In the version of the model with financial frictions, employed and unemployed household members consume different amounts of varieties but also search at different intensities. The search friction implies that high-consumption agents (the employed) consume more varieties than low-consumption agents (the unemployed), which in general requires more search. Moreover, it also implies that the market splits locations into those that cater to the employed, which requires little search because of low market tightness, and those that cater to the unemployed, which necessitates more search. In this context, the unemployed substitute their own search for resources, finding cheaper prices. This behavior is documented in the United States for retirees and the unemployed by Aguiar and Hurst (2005, 2007) and for the unemployed by Kaplan and Menzio (2013). This extended model implements two features of the process of acquiring and enjoying consumption goods: finding out about goods and looking for cheaper prices for these goods. In the model, both activities involve more searching but have different effects. We think that our model captures the essence of the data showing that the poor search more per unit of consumption or per variety.

One crucial prediction in our model is that consumers reduce their search effort during recessions. The idea is that, because consumers search less, the probability that firms will sell their products decreases. This feature occurs at the same time that the employed search more than the unemployed. Consequently, we want to make a distinction between search effort and shopping time because we do not view these efforts as identical. In our model, we interpret search effort as the disutility associated with engaging in consumption, such as waiting for a restaurant table, searching for and booking movie tickets online, and driving to an out-of-town car dealership. We interpret shopping time, on the other hand, as the time spent looking for a lower price for a particular good or service, such as clipping newspaper coupons, searching for supermarket sales, and buying goods at shopping outlets far from home. During a recession, consumers cut their spending by eating at restaurants less often, watching fewer movies, and so on. At the same time, the associated search effort also decreases, which slows business for many firms. Shopping time, however, may actually increase as consumers spend more time looking for good deals, collecting coupons, and shopping at warehouse club stores in order to obtain lower prices for the same goods. Empirically, Aguiar, Hurst, and Karabarbounis (2013) document that the shopping time increased by around 7% during the last recession. Conversely, Aguiar and Hurst (2005) show that unemployed workers and retirees spend more time shopping, but they spend eating at restaurants significantly less than employed workers do.

Related literature. A large and growing literature studies recessions generated by a disturbance to the discount factor. Recent key references include Eggertsson (2011), Christiano, Eichenbaum, and Rebelo (2011), Correia, Farhi, Nicolini, and Teles (2013), Rendahl (2012), Eggertsson and Krugman (2012), and Schmitt-Grohe and Uribe (2012). 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 novel channel for increased savings generating a recession.

To provide a rationale for our theory that financial shocks to households are a catalyst for generating recessions, we turn to evidence provided by Mian and Sufi (2010) and Mian and Sufi (2012). Using county-level data, they show that household demand is crucial in explaining aggregate economic performance and that it is also closely linked with households' financial conditions. In this context, Guerrieri and Lorenzoni (2011) consider a shock to households' borrowing capacity in an Aiyagari-type model and show that this shock causes a decline in output. The shock does so, however, by reducing the work effort of the best-performing agents—hardly what characterizes the current Great Recession. Furthermore, if combined with nominal rigidities, the financial shock can potentially push the economy into a liquidity trap. 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 and show that a drop in the leverage ratio reduces the liquidity of households and, correspondingly, their demand.

In terms of goods market frictions, Kaplan and Menzio (2013) assume that unemployed workers spend more time shopping and that total shopping time increases in recessions mechanically as the unemployment rate rises. Similarly, in Alessandria (2009), households endogenously put more effort into shopping time during recessions because of the negative wealth effect. However, in both papers firms' capacity or the probability of selling their products is constant over the business cycle, a major departure from our paper. As mentioned, this paper is closely related to Bai, Ríos-Rull, and Storesletten (2011), who show how search frictions in the goods markets can make an economy with demand shocks look like an economy with productivity shocks and that estimating the model gives strong empirical support to this view of the cycle.

This paper is also related to the literature on sudden stops and business cycles in a small open economy. Most of the literature focuses on shocks that affect the production side directly, such as shocks to TFP, investment technology, interest rate premium, terms of trade, or firms' collateral constraints. We do not consider any of those shocks; instead, we consider shocks to the households' desire to spend, which endogenously change measured TFP. In Mendoza and Yue (2012), imported intermediate goods enter the production function and a reduction of imports leads to an endogenous decline in TFP. Our approach is quite different because we want to capture the idea that it is the internal demand of households that changes the production possibility frontier.

Section 2 explains how our new mechanism works in a simple two-period version of the model. The model that can be used for quantitative analysis is described in Section 3. Calibration details are found in Section 4, and the analysis of the baseline economy is in Section 5. Section 6 describes the quantitative importance of the new mechanism involving search frictions that we develop in this paper, and we deem this mechanism to be large. Section 7 explains that in versions of the growth model with flexible prices, both adjustment costs and labor market frictions are necessary ingredients for generating recessions via household increases in savings arising from shocks in patience. Section 8 describes what happens when the baseline economy becomes suddenly poorer (wealth destruction shocks). Section 9 analyzes how our findings vary as we change some particular targets. We look at various sizes of adjustment costs in the tradable sector, at alternative job finding and losing rates, and at different wage determination protocols (staggered wage contracts and constant labor share). We also explore the performance of the model economies with respect to some other margins (elasticity of substitution between tradables and nontradables, size of vacancy costs, labor matching elasticity, goods market elasticity, and the elasticity of substitution between varieties of nontradable consumption). Throughout our analysis, all versions of the economy have been recalibrated so that it is the targets that are constant and not the parameter values that implement them. Section 10 extends the model to accommodate financial shocks as the trigger to households' increased desire to save without the need to abandon the representative agent abstraction. Section 11 concludes. A technical appendix describes technical details and provides additional tables of interest.

2 A Simple Version of the Model

In our model, households choose both the number of consumption varieties and the quantity of each variety that they consume. To see how this mechanism works, consider a simple two-period version of our model. 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. Nontradables come in different varieties that have to be searched for and found before any purchase of that variety is made. Households choose how many varieties to consume because, even though they have a taste for variety, they incur a disutility when they search. Nontradable consumption varieties provide utility via a Dixit-Stiglitz aggregator, $\left(\int_0^{\mathrm{I}} c_{Ni}^{\frac{1}{\rho}} \, d_i \right)^{\rho}$. Under equal consumption of each variety, this aggregate collapses to $c_N \, \mathrm{I}^{\rho}$.[3] We can write the utility function of the household as $u(c_T, \mathrm{I}^{\rho} c_N, d) + \beta v(b')$, where d is search effort and the second-period terms have the standard interpretation of a discount rate and an indirect utility function of savings b'. Households have an endowment of one unit of the tradable good and they can borrow or save at a zero interest rate; they also own the nontradable-producing firms.

There is a continuum of measure one of consumption varieties. Households choose how many of those varieties to consume $\mathrm{I} < 1$ by means of exerting sufficient search effort, d, to overcome a matching friction. We denote by $\Psi^d(Q^g)$ the probability that a unit of search effort finds a variety, where Q^g is market tightness in the goods market. We write the household problem as

$$\max_{c_T, \mathrm{I}, c_N, d, b'} \quad u\left[c_T, \mathrm{I}^{\rho} \, c_N, d\right] + \beta \;\; v(b') \tag{1}$$

$$c_T + \mathrm{I} \, c_N \, p + b' = \pi_N + 1, \tag{2}$$

$$\mathrm{I} = d \; \Psi^d(Q^g), \tag{3}$$

where π_N are the profits from the firms in the nontradable sector. The solution to this problem yields demand functions that, using aggregate notation (capital letters denote aggregate quantities), are $C_T(p, Q^g, \pi_N; \beta)$, $C_N(p, Q^g, \pi_N; \beta)$, $\mathrm{I}(p, Q^g, \pi_N; \beta)$, $B'(p, Q^g, \pi_N; \beta)$, and $D(p, Q^g, \pi_N; \beta)$, where we are explicitly posing the dependence on the price of nontradables, on market tightness, and on profits, as well as on the households' discount rate which we can treat as a source of shocks.

There is a continuum of measure one of firms producing the nontradables, and each one of those

[3] We deal explicitly with the determination of the price of each variety below (Section 3), where we explicitly account for the possibility of choosing different amounts for each variety.

firms has a measure one of locations. The probability that a location finds a household is $\Psi^f(Q^g) = \Psi^f(\frac{1}{D}) = M^g(D,1)$, and the probability that a search unit, or shopper, finds a variety is $\Psi^d(Q^g) = \Psi^d(\frac{1}{D}) = \frac{M^g(D,1)}{D}$. In equilibrium $\Psi^f(Q^g) = \mathrm{I}$.

Firms and consumers are matched in the nontradable goods markets according to matching function $M^g(D, T)$, where D is the aggregate search effort of households and T is the measure of firms.

The equilibrium conditions are simple given that production is predetermined:

$$Q^g = \frac{1}{D(p, Q^g, \pi; \beta)}, \tag{4}$$

$$1 = C_T(p, Q^g, \pi; \beta) + B'(p, Q^g, \pi; \beta), \tag{5}$$

$$F^N = C_N(p, Q^g, \pi; \beta), \qquad \text{or} \qquad \pi_N = p\, F^N\, \Psi^f\left(\frac{1}{D}\right). \tag{6}$$

The first condition states that market tightness is the result of household search; the second, that tradable output is either consumed or saved; and the third, that the amount of nontradable consumption of every variety is what is available at each location. Walras' law allows us to choose between the last two equations.

To see what is special in this economy, note that in standard models, $Q^g = 1$ 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 can decrease despite using all factors of production. With the preferences that we pose,[4] 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 does drop, and hence so does total output because the economy is now operating at a lower capacity. In this example, profits decrease. If this mechanism were persistent, future profits would also decrease, which is why the paradox of thrift may show up.

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. We next build these ideas into a

[4] We have the type of preferences described in Greenwood, Hercowitz, and Huffman (1988) (hereafter GHH preferences) between consumption and search effort, although many other types yield the same properties.

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.[5] There is a representative household, or a 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 that we now describe in detail.

There is a measure one of varieties of nontradables $i \in [0, 1]$, and each one is produced by a monopoly that posts prices and has to deliver the amount of goods demanded at that price. Each one of these firms or varieties has a measure one continuum of locations, each with its own capital and labor and a standard constant returns to scale (CRS) technology, $F^N(k, n)$.

Each period, consumers have to search and find varieties, and they value both the number of varieties and the quantity consumed of each variety. To obtain varieties, consumers need to search for them, incurring a shopping disutility while doing so. Shoppers that find a variety are randomly allocated to one and only one of its locations. We denote the aggregate measure of shoppers or shopping effort as D. The total number of matches between shoppers and firms is determined by a CRS matching function $M^g(D, 1)$. If we denote market tightness in the goods market by $Q^g = \frac{1}{D}$, the probability that a shopper finds a location becomes

$$\Psi^d(Q^g) = \frac{M^g(D, 1)}{D}, \tag{7}$$

and the probability that a location in each firm finds a shopper is equal to the measure of locations of each variety that is filled and is given by

$$\Psi^f(Q^g) = \frac{M^g(D, 1)}{1}. \tag{8}$$

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 $F^T(k, n)$.

[5] To ensure that this section is self-contained, some repetition with respect to the previous section may occur.

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 is

$$\Phi^w(Q^e) = \frac{M^e(U, V)}{U}. \tag{9}$$

The probability of a job vacancy being filled is

$$\Phi^f(Q^e) = \frac{M^e(U, V)}{V}, \tag{10}$$

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 in Section 3.

Preferences The representative household cares about a consumption aggregate c_A, shopping effort d, and the fraction of its members that work n. The aggregate consumption basket is valued via an Armington aggregator of tradables and nontradables, whereas nontradables themselves aggregate via a Dixit-Stiglitz formulation with a variable upper bound, yielding

$$c_A = \left(\omega \left[\int_0^{\mathrm{I}} c_{N,i}^{\frac{1}{\rho}} \ di \right]^{\frac{\rho(\eta-1)}{\eta}} + (1-\omega) c_T^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}, \tag{11}$$

where $c_{N,i}$ is the amount of nontradable good of variety i, $\mathrm{I}_N \in [0, 1]$ is the measure of varieties of nontradable goods that the household has acquired, $\rho > 1$ determines the substitutability among nontradable goods, and η controls the substitutability between nontradables and tradables. 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

$$V(S, b, n) = \max_{c_T, \mathrm{I}_N, c_{N,i}, d} u(c_A, d, n) + \beta\, \mathbb{E}\left\{V(S', b', n') \mid \theta\right\}, \tag{12}$$

subject to the definition of the consumption aggregate (11) and

$$\int_0^{\mathrm{I}} p_i(S)\; c_{N,i}\; di + c_T + b' = (1+r)b + w(S)n + \pi_N(S) + \pi_T(S), \tag{13}$$

$$\mathrm{I} = d\; \Psi^d[Q^g(S)], \tag{14}$$

$$n' = (1-\lambda)n + \Phi^w[Q^e(S)](1-n), \tag{15}$$

$$S' = G(S). \tag{16}$$

The household's budget constraint is (13). The requirement that varieties have to be found, which requires search effort d and depends on the goods market tightness, is given by (14). The evolution of the household's employment is (15), and condition (16) is the rational expectations requirement.

We define standard aggregates of nontradable consumption bundles and prices:

$$c_N = \left[\frac{1}{\mathrm{I}} \int_0^{\mathrm{I}} c_{N,i}^{\frac{1}{\rho}}\; di\right]^{\rho}, \tag{17}$$

$$p = \left[\frac{1}{\mathrm{I}} \int_0^{\mathrm{I}} p_i^{\frac{1}{1-\rho}}\; di\right]^{1-\rho}. \tag{18}$$

Note that p is not a function of I. We can derive the demand schedule for the goods from a particular variety (or firm) i, given c_N and p,

$$c_{N,i} = \left(\frac{p_i}{p}\right)^{\frac{\rho}{1-\rho}} c_N. \tag{19}$$

We can rewrite the consumption aggregate (11) and the budget constraint (14) as[6]

$$c_A = \left[\omega \left(c_N \mathrm{I}_N^{\rho}\right)^{-\eta} + (1-\omega)\, c_T^{-\eta}\right]^{-\frac{1}{\eta}}, \tag{20}$$

$$p(S) c_N \mathrm{I} + c_T + b' = (1+r)b + w(S)n + \pi_N(S) + \pi_T(S). \tag{21}$$

The first-order conditions are

$$u_{c_N} = p(S)\mathrm{I} u_{c_T}, \tag{22}$$

$$u_{\mathrm{I}} = p(S) c_N u_{c_T} - \frac{u_d}{\Psi^d[Q^g(S)]}, \tag{23}$$

$$u_{c_T} = (1+r)\mathbb{E}\left\{\beta u'_{c_T} \mid \theta\right\}. \tag{24}$$

Equation (22) shows the optimality condition between nontradable and tradable goods. Equation (23) determines the trade-off between the number of varieties and the quantity consumed of each variety: since $\rho > 1$, increasing I is more efficient than increasing c_N, but searching for different firms is costly. An implication of this equation is that in general, increases in consumption imply an increase of both the amount consumed of each variety and the number of varieties. Equation (24) is the standard Euler equation.

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:

$$C(p_i, S) = \left(\frac{p_i}{p(S)}\right)^{\frac{\rho}{1-\rho}} C_N(S). \tag{25}$$

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

$$\Omega^N(S,k,n) = \max_{p_i, i, v} \Psi^f[Q^g(S)] p_i C(p_i, S) - w(S)n - i - v\kappa + \mathbb{E}\left\{\frac{\Omega^N(S',k',n')}{1+r} \mid \theta\right\}, \tag{26}$$

[6]See Appendix A for a more detailed derivation.

subject to

$$C(p_i^c, S) \leq F^N(k, n), \tag{27}$$

$$k' = (1-\delta)k + i - \phi^N(k, i), \tag{28}$$

$$n' = (1-\lambda)n + \Phi^f[Q^e(S)]v, \tag{29}$$

$$S' = G(S), \tag{30}$$

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. The first-order conditions are

$$\frac{(1+r)}{1-\phi_i^N} = \mathbb{E}\left\{\Psi^f[Q^g(S')]p_i'(F_k^N)'\frac{1}{\rho} + \frac{1-\delta-(\phi_k^N)'}{1-(\phi_i^N)'} \mid \theta\right\}, \tag{31}$$

$$\frac{\kappa}{\Phi^f[Q^e(S)]} = \frac{1}{1+r}\mathbb{E}\left\{\Psi^f[Q^g(S')](p_i^c)'(F_n^N)'\frac{1}{\rho} - w(S') - \frac{(1-\lambda)\kappa}{\Phi^f[Q^e(S')]} \mid \theta\right\}. \tag{32}$$

Equations (31) and (32) equate the marginal benefits and marginal costs of increasing investment and vacancies. All firms choose the same price in equilibrium, i.e., $p_i = p(S)$ 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

$$\Omega^T(S, k, n) = \max_{i,v} F^T(k, n) - w(S)n - i - v\kappa - \phi^{T,n}(n', n) + \mathbb{E}\left\{\frac{\Omega^T(S', k', n')}{1+r} \mid \theta\right\}, \tag{33}$$

subject to

$$k' = (1-\delta)k + i - \phi^{T,k}(k, i), \tag{34}$$

$$n' = (1-\lambda)n + \Phi^f[Q^e(S)]v, \tag{35}$$

$$S' = G(S). \tag{36}$$

The first-order conditions are

$$\frac{1+r}{1-\phi_i^{T,k}} = \mathbb{E}\left\{ (F_k^T)' + \frac{1-\delta-(\phi_k^{T,k})'}{1-(\phi_i^{T,k})'} \mid \theta \right\}, \tag{37}$$

$$\frac{\kappa}{\Phi^f[Q^e(S)]} + \phi_{n'}^{T,n} = \frac{\mathbb{E}\left\{ (F_n^T)' - w(S') - (\phi_n^{T,n})' + (1-\lambda)\frac{\kappa}{\Phi^f[Q^e(S')]} \mid \theta \right\}}{1+r}. \tag{38}$$

Equations (37) and (38) are similar to the optimality condition for nontradable firms. When necessary, we use the subindex T to refer to tradables.

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.[7] The value of an additional employed worker for the household with wage w is

$$\widetilde{V}_n(w,S) = w u_{c_T}(S) - \varsigma + \beta\big(1-\lambda-\Phi^w[Q^e(S)]\big)\mathbb{E}\{V_n(S') \mid \theta\}, \tag{39}$$

where $V_n(S) = \widetilde{V}_n(w(S), S)$ and $u_{c_T}(S)$ is the marginal utility for the representative household. The value of an additional worker for a firm in the nontradable goods sector with wage w is

$$\widetilde{\Omega}_n^N(w,S) = \Psi^f[Q^g(S)]p(S)F_n^N(S)\frac{1}{\rho} - w + \frac{(1-\lambda)}{1+r}\mathbb{E}\{\Omega_n^N(S') \mid \theta\} \tag{40}$$

and for a firm in the tradable goods sector is

$$\widetilde{\Omega}_n^T(w,S) = F_n^T(S) - w - \phi_n^{T,n}(S) + \frac{(1-\lambda)}{1+r}\mathbb{E}\{\Omega_n^T(S') \mid \theta\}, \tag{41}$$

where $\Omega_n^N(S) = \widetilde{\Omega}_n^N(w(S), S)$ and $\Omega_n^T(S) = \widetilde{\Omega}_n^T(w(S), S)$. Firms may not value workers equally, that is, $\widetilde{\Omega}_n^T$ may not be the same as $\widetilde{\Omega}_n^N$. We assume that the wage that is set in the market is the outcome from a bargaining process between a representative worker and a weighted value of the valuation of the worker by firms, with weights given by the employment share of each sector.

[7] 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).

With these elements, the Nash bargaining problem becomes

$$w(S) = \max_{w} \left[\widetilde{V}_n(w,S)\right]^{\varphi} \left[\chi(S)\widetilde{\Omega}_n^N(w,S) + (1-\chi(S))\widetilde{\Omega}_n^T(w,S)\right]^{1-\varphi}, \tag{42}$$

where φ is the bargaining power of households and $\chi(S) = \frac{n_N}{n_N+n_T}$ is the employment share of the nontradable goods sector. Taking the derivative with respect to w yields the first-order condition

$$\varphi u_{c_T}(S) \left[\chi(S)\widetilde{\Omega}_n^N(w,S) + (1-\chi(S))\widetilde{\Omega}_n^T(w,S)\right] = (1-\varphi)\widetilde{V}_n(w,S). \tag{43}$$

In steady state, the wage rate is given by

$$w = \varphi \left[\chi \left(\Psi^f(Q^g) p F_n^N \frac{1}{\rho}\right) + (1-\chi)F_n^T + Q^e \kappa\right] + (1-\varphi)\frac{\varsigma}{u_{c_T}}. \tag{44}$$

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.[8]

We will also explore staggered wage environments in which wages are set through Nash bargaining, but the workers and firms can only renegotiate contracts with a certain probability. In Section 9, we investigate how wage rigidity affects the model's performance.

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

Equilibrium Equilibrium is a set of decision rules and values for the household: $\{c_N, c_T, d, \mathrm{I}, b', V\}$ 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 aggregate variables for nontradable goods C_N and tradable goods C_T, total employment N, total vacancies V, total shopping effort D, labor market tightness Q^e, goods market tightness Q^g, total bond holdings B, aggregate capital $\{K_N, K_T\}$, employment $\{N_N, N_T\}$, investment $\{I_N, I_T\}$, vacancies $\{V_N, V_T\}$, and profits $\{\pi_N, \pi_T\}$ in both sectors, the aggregate price index p, and the wage rate w 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.

[8] A minor departure from the standard labor search model is that the wage rate has a dynamic component under uncertainty. The reason is that firms discount future profits using the world interest rate r instead of the households' stochastic discount factor.

2. Individual decisions are consistent with aggregate variables.

3. The wage rate w is determined via the Nash bargaining process (42).

4. Tradables and nontradables markets clear.

Note that in equilibrium, $\mathrm{I} = \Psi^f(Q^g)$ (i.e., consumers' demand directly translates into firms' capacity). Also note that this economy may have multiple steady states with varying foreign asset positions.[9] 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 Calibration

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 (NIPA) (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 (Section 4.3).

4.1 NIPA and Variable Definitions Issues

Real output is given by

$$Y = p^* \Psi^f(Q^g) F^N(K_N, N_N) + F^T(K_T, N_T), \tag{45}$$

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 $C = p^* \mathrm{I} C_N + C_T$. Total employment is $N = N_N + N_T$. Total capital is $K = K_N + K_T$. Total investment is $I = I + I_T$. Let υ denote the labor share in steady state. Total factor productivity or the measured Solow residual, Z, is defined as

$$Z = \frac{Y}{K^{1-\upsilon} N^{\upsilon}}. \tag{46}$$

[9] A stationary recursive equilibrium for the stochastic version requires $1 + r < \beta^{-1}$ because of precautionary savings. Given the small quantitative nature of these issues, we ignore them in the discussion that follows.

4.2 Functional Forms and Parameters

Preferences We adopt GHH preferences between consumption and shopping effort, which suffices to yield that consumption per variety and the number of varieties move together, making measured TFP procyclical. Other specifications do not have this property (see Appendix B for a more detailed discussion). 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

$$u(c_A, d, n) = \frac{1}{1-\sigma}\left(c_A - \xi d\right)^{1-\sigma} - \varsigma n. \tag{47}$$

The units for search effort do not matter. We write ξ only because we have a steady-state target for d.

The preference parameters are the discount factor β, the risk aversion parameter of sorts, σ, the parameter that determines average shopping effort ξ, and the working disutility ς. As discussed before, c_A, the aggregator of consumption, is

$$c_A = \left[\omega\left(c_N \mathrm{I}_N^{\rho}\right)^{\frac{\eta-1}{\eta}} + (1-\omega)c_T^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \tag{48}$$

where η 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

$$F^N(k, n) = z_N\, k^{\theta^N}\, n^{1-\theta^N}, \tag{49}$$

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

$$F^T(k, n) = z_T\, k^{\theta_k^T} n^{\theta_n^T}\, L^{1-\theta_k^T-\theta_n^T} = z_T k^{\theta_k^T} n^{\theta_n^T}. \tag{50}$$

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

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

$$\phi^N(k, i) = \frac{\epsilon^N}{2}\left(\frac{i}{k} - \delta\right)^2 k, \tag{51}$$

where δ is the capital depreciation rate and ϵ^N determines the size of the adjustment cost. Similarly, the capital adjustment cost in the tradable goods sector is

$$\phi^{T,k}(k,i) = \frac{\epsilon^{T,k}}{2}\left(\frac{i}{k} - \delta\right)^2 k. \tag{52}$$

In addition to the capital adjustment cost, producing for tradable goods also involves adjustment costs in employment,

$$\phi^{T,n}(n',n) = \frac{\epsilon^{T,n}}{2}\left(\frac{n'}{n} - 1\right)^2 n. \tag{53}$$

Nash Bargaining Workers' bargaining power is φ.

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

$$M^e(U,V) = \nu^e U^\mu V^{1-\mu}, \tag{54}$$

$$M^g(D,T) = \nu^g D^\alpha T^{1-\alpha}, \tag{55}$$

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

Wealth This economy has a continuum of steady states differing in the net foreign asset position. Here, we look at the steady state with a zero net foreign asset position.

4.3 Targets and Values

We choose a period to be six weeks so that the unemployment duration can be short. A first group of 5 parameters can be determined exogenously (i.e., they imply targets that are independent of the equilibrium allocation). Table 1 summarizes the targets and the implied parameter values. 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, the benchmark value used in Bianchi (2011), which is also similar to the value estimated by Heathcote and Perri (2002). 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.[10] 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 this parameter should be. Basu and Fernald (1997), using micro reasoning, claim that the implied markup is not significantly greater than 1

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

(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 $\rho = 1.05$.

TABLE 1
Exogenously Determined Parameters of the Baseline Economy

Parameter	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	0.83
Price markup ρ	1.05

The second group of parameters is not the direct implication of any single target, but can be determined by steady-state conditions, which requires the specification of sufficient steady-state moments. There are 14 such parameters: 3 preference parameters, $\{\omega, \xi, \varsigma\}$, 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 3 labor market parameters $\{\varphi, \lambda, \kappa\}$. Table 2 lists the steady-state targets and associated parameters for the baseline economy.[11] Although many of the parameters in Table 2 have economic meaning, others are just the determinants of units. Accordingly, the table displays the unit parameters separately.

The targets of the job flows are standard: an employment rate of 93% to accommodate movements in labor force participation and a monthly job finding rate of 45%. 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 30%. 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 target a vacancy posting cost to output ratio of 0.0374. The literature has few direct estimates of this vacancy cost. Silva and Toledo (2009) report the flow vacancy costs to be 4.3% of the quarterly wage and the training costs to be 55% of the quarterly wage. We consider the vacancy costs as the sum of all of these recruitment-related costs.[12] Hagedorn and Manovskii (2008) and Shimer (2012) have a smaller

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

[12] In the robustness check, we will show that by targeting a smaller value of the vacancy costs, the model results

vacancy cost because they take only the flow vacancy cost into account. 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 target the value of the unemployment (or leisure) $\frac{\varsigma}{u_{c_T}}$ to wage ratio of 0.35, and it turns out that the bargaining power $\varphi = 0.42$, which is in the middle of those two polar cases. We also target an annual capital-output ratio of 2.75.

TABLE 2
Steady-State Targets and Associated Parameters of the Baseline Economy

Target	Value	Parameter	Value
Share of tradables, $\frac{F_T^*}{Y^*}$	0.3	ω	0.91
Unemployment rate, U^*	7%	λ	0.05
Monthly job finding rate	45%	ν^e	0.67
Occupancy rate, $\frac{C_N^*}{F_N^*}$	0.81	ν^g	0.81
Capital to output ratio, $\frac{K^*}{Y^*}$	2.75	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
Vacancy posting to output ratio	0.037	κ	0.53
Value of leisure to wage ratio	0.35	φ	0.42
Units Parameters			
Output, Y^*	1	z_N	0.45
Relative price of nontradables, p^*	1	z_T	0.52
Market tightness in labor markets, $\frac{U^*}{V^*}$	1	ς	0.54
Market tightness in goods markets, D^*	1	ξ	0.02

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 value of leisure ς, and the parameter that transforms search units into utils, ξ.

The last group of parameters has no steady-state implications, and we set these parameters according to their dynamic implications (see Table 3). We choose the capital adjustment cost in the nontradable goods sector ϵ^N such that the immediate response of nontradable investment i_N is four

are improved. Therefore, the target we use here should be considered as a conservative benchmark.

Table 3
Dynamically Calibrated Parameters of the Baseline Economy

Target	Value	Parameter	Value
Response of nontradable investment	$\frac{\Delta I^N}{\Delta Y^N} = 4$	ϵ^N	14.17
Response of tradable output	$\frac{\Delta Y^T}{\Delta Y} = -5$	$\epsilon^{T,n}$	7.70
Symmetry of tradable adjustment costs	$\epsilon^{T,k} = \epsilon^{T,n}$	$\epsilon^{T,k}$	7.70
Response of labor to output	$\frac{\Delta N}{\Delta Y} = .5$	α	0.22

times as large as the response of nontradable output Y_N at its lowest point. That is, we want a 1% increase (decrease) in nontradable output in our exercises to be associated with a 4% decrease in investment in nontradables. We want output in the tradable sector to expand by 5% when total real 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 such that when total output declines by 1%, the employment rate decreases by 0.5%.

5 A Recession Induced by a Shock to the Discount Factor

We are now ready to explore the properties of recessions induced by households' attempt to save more. We use relatively permanent shocks to the discount factor as a proxy for financial shocks, but in Section 10 we extend the model so as to accommodate explicit financial shocks that make consumption smoothing difficult.

A household that suffers a shock to its patience wants to work harder and save more by reducing its consumption of both tradables and nontradables. Its willingness to work more translates to a wage drop but not in more work unless firms pose more job vacancies. Less tradable consumption translates directly into more net exports. 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, the output and profits of nontradables 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 to the adjustment costs that slow its expansion.

Specifically, consider the following AR(1) stochastic process: $\log \tau_t = \rho^{\tau} \log \tau_{t-1} + \varepsilon_t$, $\varepsilon_t \sim N(0, \sigma^{\tau})$, with persistence $\rho^{\tau} = 0.95$. Now consider the following version of the utility function:

$$\mathbb{E}\left\{\sum_{t=0}^{\infty} \tau_t \beta^t u(c_t, d_t, n_t)\right\}. \tag{56}$$

Our strategy is to look for an innovation ε_t capable of reducing real output by 1%. Clearly, the lower the required value of ε_t, the more vulnerable the economy is to recessions.

Performance of the Baseline Economy The first row of Table 4 displays the size and the sign of the innovation of the shock required to produce a drop in output of 1%, as well as the implied change of employment, of the measured Solow residual, and of total consumption. The size of the temporary increase in the discount rate is a little less than 1%. By itself, this statistic does not tell us much, but it is useful for comparisons. Recall that the economy was calibrated to generate a drop in employment of 0.5%. We see that there is a reduction in measured TFP of 0.69% and that consumption drops by 3.8%. The reduction of nontradable consumption is responsible for the reduction in measured TFP.

Figure 2 displays the impulse responses of the main macroeconomic variables to the shock in the baseline economy (blue dots). Here are eight interesting features of the ensuing recession beyond those that we imposed (i.e., the 1% drop in output and the 0.5% drop in employment):

1. The Solow residual drop of 0.69% lingers for a while and does not recover its original value for at least five years.

2. Employment recovers quite fast, within a year.

3. Consumption drops about 4% and recovers slowly. The drop is much higher for tradables than for nontradables: the price of the latter drops quite dramatically, about 15%.

4. The large increase in the output of tradables is due to an increase in net exports, which jumps to 3.5% of GDP as investment suffers quite a large reduction, almost 8%.

5. The drop in nontradable consumption is due to both the number of consumption varieties and the quantity consumed of each variety, albeit more of the latter.

6. Wages measured in tradables goods drop quite dramatically, almost 10%.

Figure 2

Impulse Responses in the Baseline Economy and in the Economy without Goods Markets Frictions

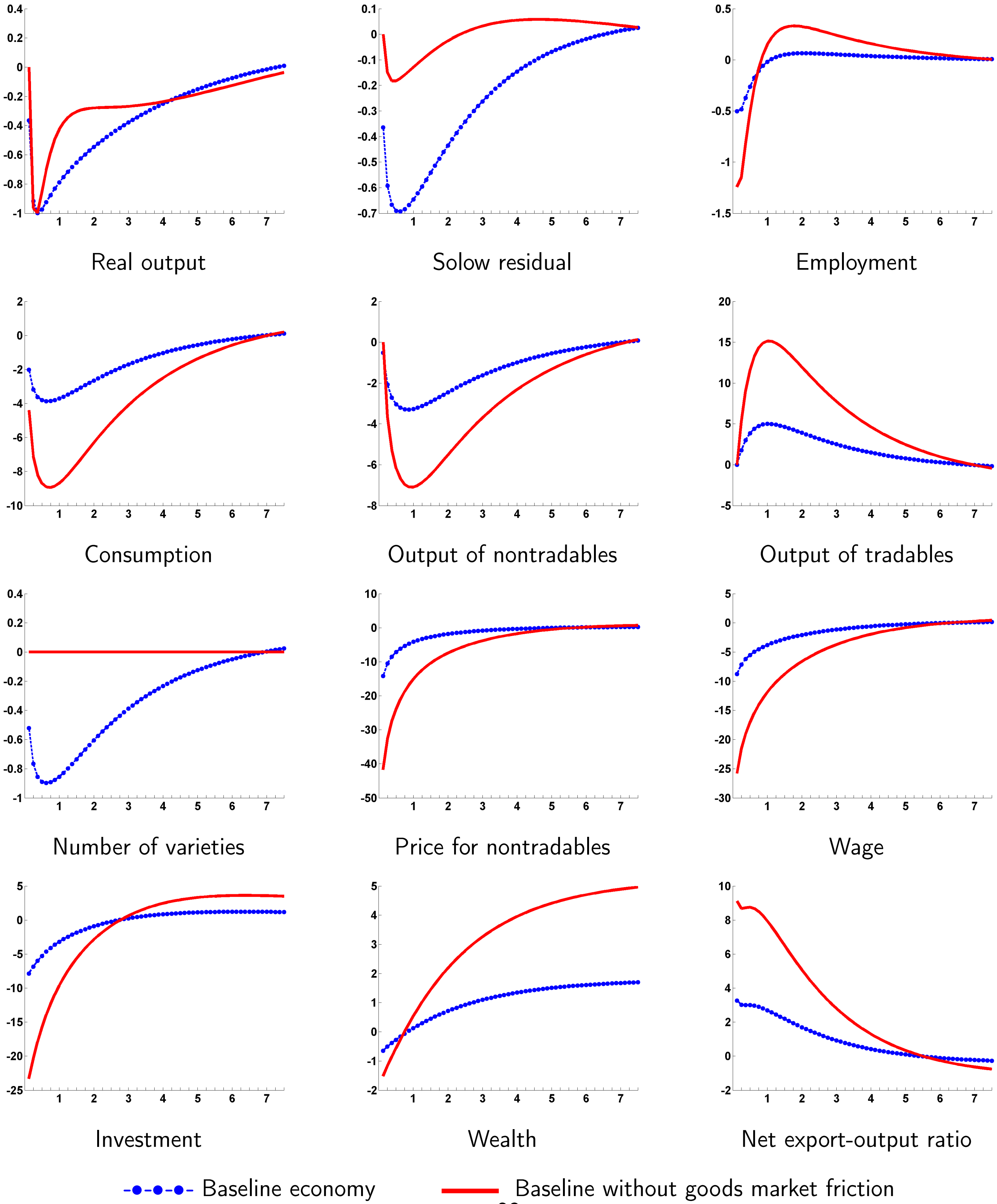


Table 4
Statistics for a 1% Drop in Output Generated
by Shocks to the Discount Factor in Various Economies

Model economy	Pref Shock	Employment	TFP	Consumption
Baseline economy	**0.88**	-0.50	**-0.69**	-3.86
Baseline without goods market friction	**2.00**	-1.22	**-0.16**	-7.50
Baseline with very low adjustment costs	1.29	0.12	-1.80	-8.39
Frictionless markets	**-0.48**	-1.77	0.00	4.18
Frictionless labor with goods market friction	**-0.53**	-1.96	0.10	4.50
Baseline + high adjustment cost	0.66	-0.80	-0.47	-2.49
Baseline + lower job finding rate + same dynamic parameters	0.90	-0.38	-0.72	-4.03
Baseline + lower job finding rate + new dynamic parameters	0.95	-0.50	-0.65	-4.00
Baseline + staggered wage	0.55	-0.78	-0.50	-2.67
Baseline + staggered wage + high adj. costs	0.45	-0.94	-0.40	-2.03
Baseline + constant labor share	0.85	-0.51	-0.67	-3.75
Baseline w/o goods market friction and high adj. costs	1.10	-1.36	-0.09	-3.40
Baseline w/o goods market friction and staggered wages	0.90	-1.37	-0.13	-3.69
Baseline w/o goods market friction and constant labor share	1.88	-1.22	-0.16	-7.11

7. A paradox of thrift arises. Despite households' attempt to increase savings, the value of wealth is reduced for a few periods, as measured by the sum of the foreign bonds and the present discounted sum of profits, $W_t = (1+r)b_t + \sum_{k=t}^{\infty} \frac{\pi_{N,k}+\pi_{T,k}}{(1+r)^{k-t}}$. It takes roughly a year for wealth to recover its initial level. Eventually, wealth increases by 1.6%.

8. A massive increase in net exports of about 3.5% occurs. In the long run, the economy has a current account deficit because of its long-run positive net foreign asset position.

To summarize, in the baseline economy, an increase in savings generates a long-lasting recession with loss of both employment and productivity, reductions in consumption and investment, and an increase in net exports. As stated before, all of these features are consistent with the experience in southern Europe (see Figure 1).

6 The Role of Frictions in the Goods Market

To consider the quantitative importance of the mechanism that is novel in this paper, 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 works at full capacity. [13]

The second row in Table 4 shows that to get a 1% recession, the size of the shock required in an economy without the goods market friction is 2.00%, 2.3 times larger than in the baseline and a very large number. Moreover, such a recession is made up of a 1.22% reduction in employment and a 0.16% reduction in TFP (which comes from the decreasing returns to scale of the tradable goods sector).

The solid red lines in Figure 2 show the dynamic paths of this economy. In the absence of the shopping friction, the requirements for the recession are dramatic: a reduction of consumption of 7.5% rather than 4%, a reduction of investment of 22% rather than 8%, and also enormous reductions in the wage rate (over 20%) and in the price of nontradables (over 40%). We conclude that the contribution of consumers to the determination of productivity is a major ingredient for the understanding of business cycles.

7 The Role of Adjustment Costs and Frictions in the Labor Market

Adjustment costs and labor market frictions are crucial to generate savings induced recessions.

Adjustment Costs Nontrivial adjustment costs is a required ingredient of the recession. To see this, it suffices to look at the third row of Table 4 which displays an economy like the baseline except that adjustment costs are almost zero, $\epsilon^{T,k} = \epsilon^{T,n} = 0.01$ (recall that the value in the baseline is 7.7). Now a shock that is 50% larger than that in the baseline generates a 1% drop in output but a small increase in employment. The recession comes about only because of the lower productivity implied by consumption in nontradables and lower shopping. The implied drop in consumption is much larger, more than two times larger than in the baseline.

Frictions in the Labor Market The labor market friction prevents the household from choosing how much to work. In our economy, a shock to patience induces households to be willing to reduce consumption and increase labor today relative to tomorrow. If households are able to choose how much to work, the economy will yield an increase in labor, thereby generating an expansion, not a recession. This occurs because the households are willing to accept a lower wage to delay gratification.[14] Therefore, in our economy with competitive markets, it is a reduction of patience

[13]Appendix C includes a more detailed description of this model economy and the economies without labor market frictions.

[14]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 (2011), Schmitt-Grohe

that generates a recession with lower work and higher wages. Figure 3 and the fourth and fifth rows of Table 4 show the performance of two versions of the baseline economy with no labor market frictions, one with and one without goods markets frictions, and we compare them with the performance of the baseline economy. Except for output and employment, all the other aggregate variables move in a direction opposite from the baseline: the tradable sector shrinks, the nontradable sector expands, consumption increases and net exports decrease. The shock needed to induce a 1% decrease in output is larger when the goods market friction exists. This is because the larger demand for nontradable goods also increases the Solow residual, which is countercyclical in this context.

8 Shocks to Wealth

We now engineer a recession by a sudden reduction in the net foreign asset position. We set the size of the reduction to reduce output in the long run by 1% starting from a steady state with a zero net foreign asset position. This exercise explores the implication that when households become impoverished, they lower their consumption, which brings about a permanent drop in output and the Solow residual. We think that such a wealth shock is a good description 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.

We model this shock as an unexpected onetime shock ϵ^w to the households' budget constraint:

$$p(S)c_N\mathrm{I} + c_T + b' = (1+r)(b - \epsilon^w) + w(S)n + \pi_N(S) + \pi_T(S). \tag{57}$$

In the first row of Table 5, we list the size of the shock as a percentage of initial total wealth. This is a sizable shock, since the total value of wealth in this economy is about five times the yearly output. As shown in the second row the size of the shock in a version of the economy without the shopping friction is twice as large as in the baseline.

Figure 4 covers the first 10 years after the shock. The changes are now permanent. 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 perma-

and Uribe (2011), and Heathcote and Perri (2012).

FIGURE 3
Impulse Responses in the Baseline Economy and in the Economies without Labor Market Frictions

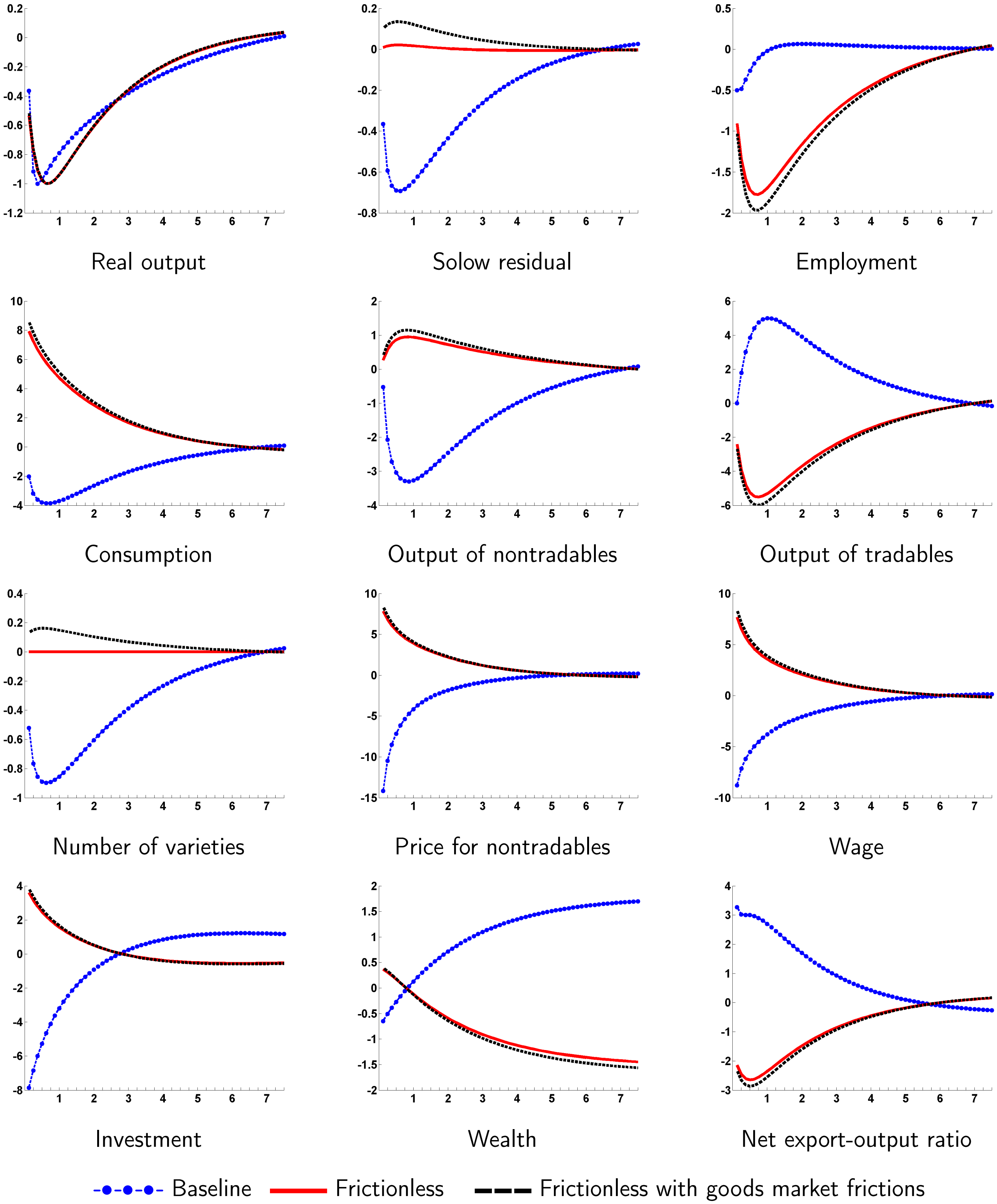


TABLE 5
Statistics for Wealth Shock to Induce 1% Output Drop

Model Economy	Wealth Shock	Employment	TFP	Consumption
Baseline	9.51	-0.21	-0.37	-3.07
Baseline, no shopping	18.74	-0.39	-0.05	-4.57

nent decline in wages, which will encourage 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 fairly quickly, and it inherits the statistical properties of the shock. Other aggregate variables follow a similar pattern. With a shock to wealth, output, the Solow residual, and consumption transit to a quite different and lower steady state.

Southern European economies have stagnated for a relatively long time. From this point of view, a shock to wealth looks more like a plausible trigger than a shock that just increases the desire to save (e.g., a shock to the discount factor) because some aggregate variables such as output and consumption do not recover. However, under the baseline calibration, neither the β shock nor the wealth shock produces a slow recovery in employment. If we add staggered wage contracts to the baseline model, employment takes about two years to return to its original level, as shown in Table 6. Further, if we combine both staggered wage contracts and high adjustment costs in the tradable sector, employment takes more than three years to fully recover when the recession is triggered by a wealth shock. Figure 5 compares the impulse responses in economies with β shocks and wealth shocks, both of which adopt staggered wage contracts and high adjustment costs in the tradable sector.

9 Various Other Alternatives to the Baseline Economy

We now explore variations of the baseline economy that sharpen the characterization of how adjustment costs, wage setting mechanisms, the shopping friction, and labor market turnover affect recessions. Appendix C includes a detailed study of the various other alternatives to the

Figure 4
Impulse Responses of Shocks to Wealth
in the Baseline Economy and in the Economy without Goods Markets Frictions

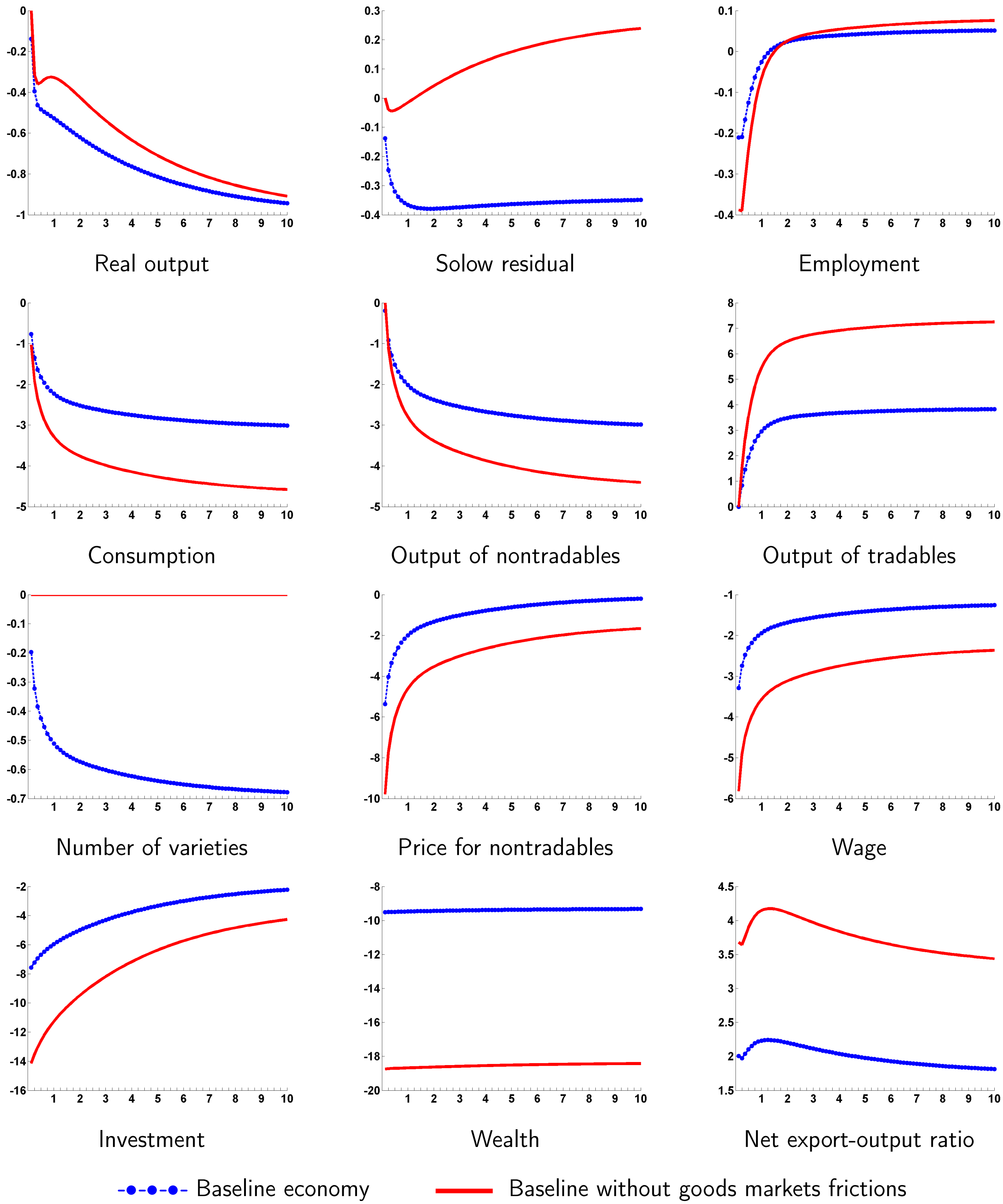


FIGURE 5
Impulse Responses of Shocks to β and Shocks to Wealth
with Staggered Wage Contracts and High Adjustment Costs

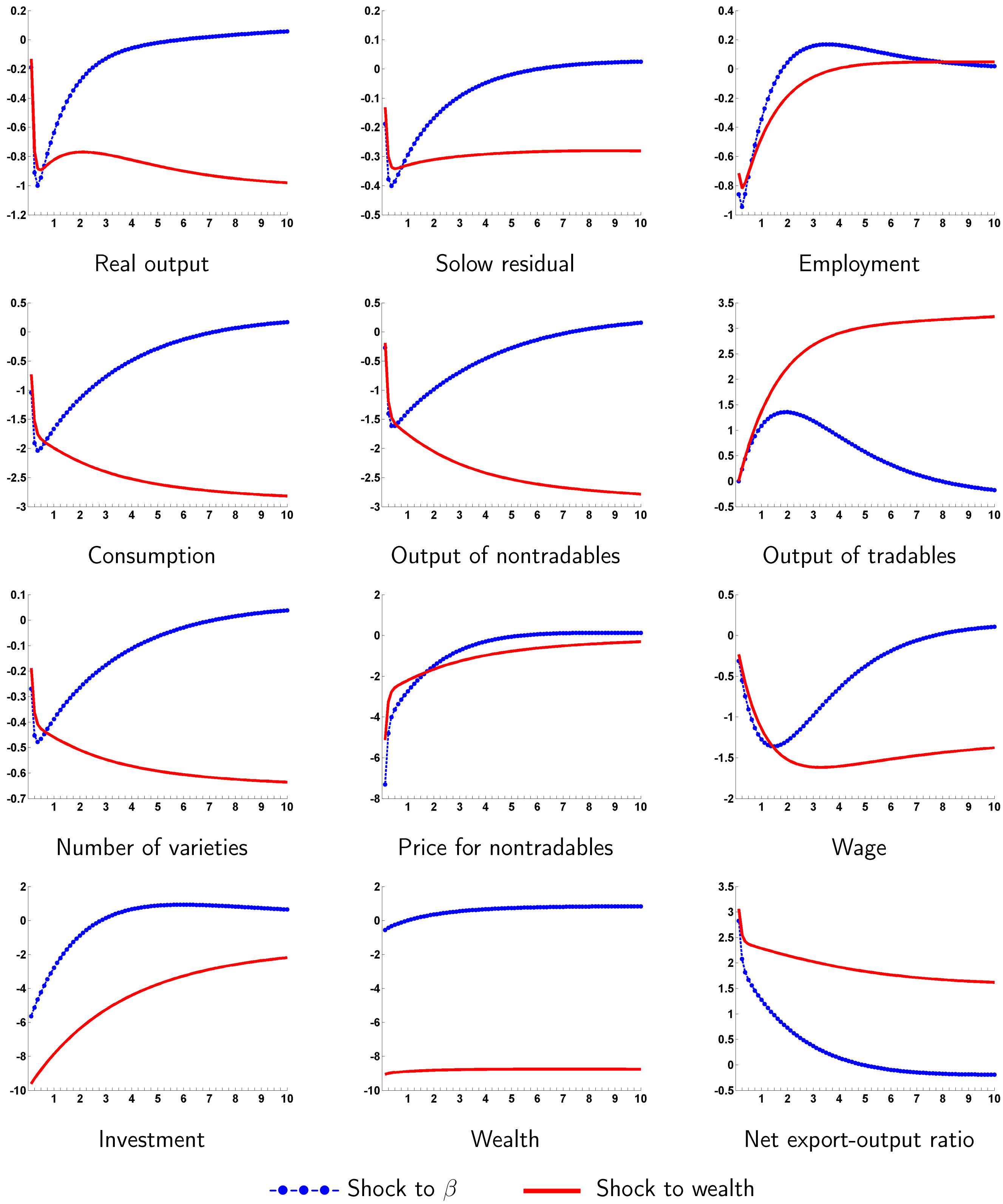


Table 6
Statistics for β Shock and Wealth Shock to Induce 1% Output Drop

Model Economy	Employment	TFP	Consumption	Recovery Time
β shock	-0.50	-0.72	-4.50	4
β shock + staggered wage	-0.85	-0.47	-2.72	7
β shock + staggered wage + high cost	-1.02	-0.36	-2.03	9
Wealth shock	-0.21	-0.37	-3.44	2
Wealth shock + staggered wage	-0.46	-0.43	-3.44	9
Wealth shock + staggered wage + high cost	-0.82	-0.46	-3.25	14

Note: Recovery time is the number of quarters it takes employment to recover its initial steady-state level.

baseline economy and also the robustness analysis when using different calibration targets.

High Adjustment costs in the Tradable Goods Sector We increase the adjustment costs for labor and capital in equal magnitude ($\epsilon^{T,n} = \epsilon^{T,k}$) to reduce the expansion of the tradable sector to 2% instead of 5%. The sixth row of Table 4 shows that the size of the shock needed to generate a 1% reduction in output is about 75% of that in the baseline economy, but now the drop in employment is larger (0.80%) and that of TFP smaller (0.47%) because of the lower employment creation in tradables. The dynamic analysis (shown in Appendix C in Figure 8) shows a smaller (2.5%) reduction in consumption and a larger (9%) reduction in investment relative to the baseline economy, whereas the drop in the wage is smaller. As in the baseline economy, a paradox of thrift also occurs, but this time the final increase in wealth is about half of that in the baseline. Not only is there a larger drop in employment compared with the baseline model, but it also takes longer for employment to recover. In an economy with no adjustment costs, total employment will not decrease at all; instead, there would be an export-based expansion. We take this result as evidence that the tradable sector has to have sizable adjustment costs.

Low Labor Market Turnover Southern European economies are characterized by having a much less dynamic labor market than that of the United States or northern Europe. To explore the implications of smaller flows in and out of employment, we pose two economies with a lower job finding rate. The seventh row of Table 4 displays the size of the required shock for a 1% output reduction and its associated decomposition into employment and measured productivity of an economy calibrated to have the same steady state as the baseline except for having a monthly job finding rate of 22% (one-half of that of the baseline) and an unemployment rate of 10% (7% in the baseline). The dynamic parameters have not changed. We see that the size of the shock is very similar to that of the baseline and that the reduction in output is due more to a reduction in productivity than in the baseline. The eighth row of Table 4 displays the results for a low labor market turnover economy in which the adjustment costs have been increased to have the same employment response as in the baseline (0.5%). The required shock is a bit higher but not by too much. We conclude that our main findings are robust to the amount of labor market turnover.

Staggered Wage Contracts à la Calvo In the baseline economy, despite the holdup problem implied by Nash bargaining with labor search frictions, there is a large drop in wages. An extensive literature (see Hall (2005), for example) documents that adding wage stickiness can help Mortensen-Pissarides type models to account for employment volatility. In this section, we examine the role of wage stickiness in a Calvo-style wage contracting environment, similar to Gertler and Trigari (2009). We assume that, every period, a fraction θ_w of employed workers have the chance to renegotiate their wages with firms.[15] We set $\theta_w = 12.5\%$, so that the average duration of a wage contract is one year. The ninth row of Table 4 displays the required shock size and the decomposition of the fall in output into labor and productivity. As we expected, the required size of the shock is much smaller than in the baseline. Moreover, most of the fall in output is due to a fall in employment. The drop in consumption is also much smaller.

Figure 6 compares the impulse responses to the patience shock in the baseline economy and the staggered wage economy. Comparing the two sets of impulse responses, we see large differences among them. In the staggered wages economy, there is a larger initial drop in employment that reverses after three years. There are also slower drops in consumption and nontradables but a smaller increase in tradables. After the initial drop in wealth that also displays the paradox of thrift, the eventual increase in wealth is lower than in the baseline economy.

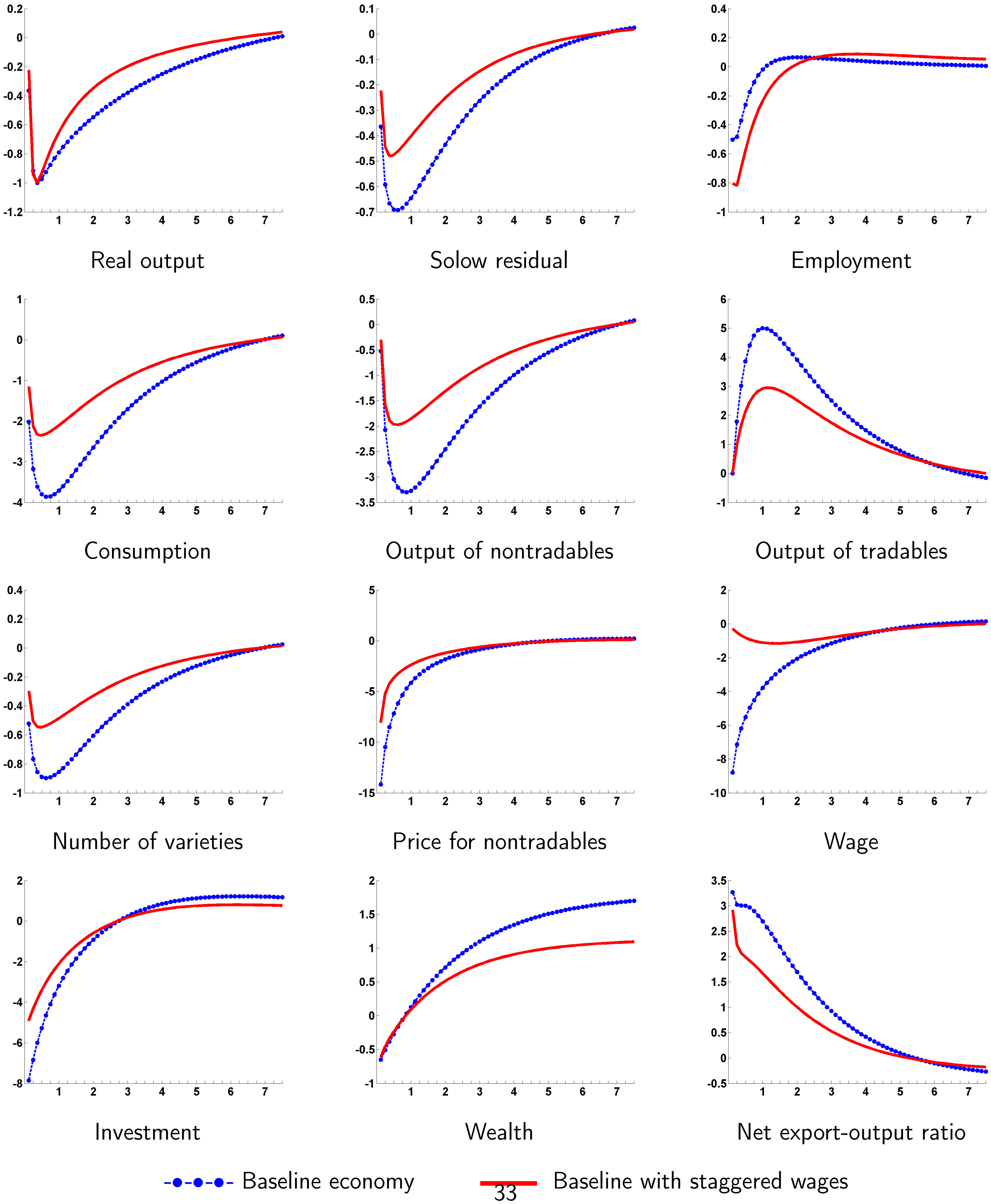
Both Staggered Wages and High Adjustment Costs With these two frictions together, the required size of the shock is about 50% of that of the baseline (tenth row of Table 4). In this case, the drop in labor is almost as large as that of output.

Constant Labor Share To get a sense of the role of different forms of wage setting, the eleventh row of Table 4 displays an economy with constant labor share. Its performance is quite similar to

[15] Again, Appendix C gives the details of the specification of this economy.

Figure 6

Impulse Responses in the Baseline and Staggered Wage Economies



the baseline with Nash bargaining wage setting: the size of the shock required to generate a 1% reduction in output is slightly smaller than in the baseline (0.85 versus 0.88).

The Role of Shopping in Alternative Economies In the last three rows of Table 4 we report nonshopping versions of economies with high adjustment costs, staggered wages, and constant labor share. As before, the size of the shock is also much larger than in the shopping counterpart.

10 Economies with Financial Frictions

Shocks to patience are not what we have in mind as a trigger for increased savings. We now extend our model to allow a limited form of heterogeneity within the household that is capable of accommodating shocks to the financial system that trigger changes in savings. We assume financial costs to providing unemployment insurance, implying that employed and unemployed workers may have different consumption levels. These costs are lower when wealth is higher because the transfers of the employed to the unemployed become smaller. Let ψ be a financial cost per unit of transfer to unemployed workers. 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 similar effects than shocks to the discount factor.

In this economy employed and unemployed agents search in different goods markets with different prices, different market tightness, and different amounts consumed. In other words, goods markets can be segmented.[16] In this economy the unemployed care relatively more than the employed for lower prices relative to search intensity, which generates a rationale for firms to price discriminate. Firms will gear some of their locations to cater to unemployed workers and the rest 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 wage determination mechanism of the financial friction economy maintains a constant labor share. The firm's problem is

$$\Omega^N(S,k,n) = \max_{\substack{i,v,x^e,p^e_j\\ x^u,p^u_j}} x^e p^e_j \Psi^f(Q^{g,e}) C^e(p^e_j,S) + x^u p^u_j \Psi^f(Q^{g,u}) C^u(p^u_j,S) - w\ell - i - \kappa v + \frac{\Omega^j(k',n')}{1+r^*} \tag{58}$$

[16] Appendix D describes a version of this economy with nonsegmented goods markets. We think of these two versions of the model as extreme cases of a general version in which there are different goods markets for the two types of agents, but some noise sends them to the wrong market.

subject to

$$
\begin{aligned}
F^N(k,n) &\geq x^e C^e(p_i^e, S) + x^u C^u(p_i^u, S), && (59)\\
x^e + x^u &\leq 1, && (60)\\
k' &= (1-\delta)k + i - \phi^N(k,i), && (61)\\
n' &= (1-\lambda)n + \Phi^f[Q^e(S)]v, && (62)\\
S' &= G(S). && (63)
\end{aligned}
$$

To have an equilibrium where firms enter both markets, the following conditions have to be satisfied:

$$p^e \Psi^f(Q^{g,e}) = p^u \Psi^f(Q^{g,u}) = \zeta, \tag{64}$$

$$c_N^e = c_N^u = F^N(K_N, N_N). \tag{65}$$

The market tightness in equilibrium equals

$$Q^{g,e} = \frac{X^e}{nD^e}, \qquad Q^{g,u} = \frac{X^u}{(1-n)D^u}. \tag{66}$$

Satisfying (66) 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. The problem of the household is

$$V(S,b,n) = \max_{\substack{c_T^e, \mathrm{I}^e, p^e \\ c_T^u, \mathrm{I}^u, p^u}} nu(c_A^e, d^e, 1) + (1-n)u(c_A^u, d^u, 0) + \beta\, \mathbb{E}\{V(S', b', n') \mid \theta\} \qquad \text{s.t.} \tag{67}$$

$$
\begin{aligned}
& n[p^e(S)\mathrm{I}^e c_N^e + c_T^e] + \\
& \qquad (1-n)[p^u \mathrm{I}^u c_N^u + c_T^u] = (1+r)b + w(S)n + \pi_N(S) + \pi_T(S) - \psi(1-n)\mathrm{T}_r - b'. && (68)\\
& \qquad\qquad \mathrm{T}_r = p^u \mathrm{I}^u c_N^u + c_T^u - [(1+r)b + \pi_N(S) + \pi_T(S)], && (69)\\
& \qquad\qquad \mathrm{I}^s = \Psi^d(Q^{g,s})\, d^s, \qquad \text{for } \ s \in \{e,u\} && (70)\\
& \qquad\qquad n' = (1-\lambda)n + \Phi^w[Q^e(S)](1-n), && (71)\\
& \qquad\qquad \zeta = p^e \Psi^f(Q^{g,e}) = p^u \Psi^f(Q^{g,u}), && (72)\\
& \qquad\qquad c_N^e = c_N^u = F^N(K_N, N_N), && (73)\\
& \qquad\qquad S' = G(S). && (74)
\end{aligned}
$$

The first-order conditions for the multiple market environment can be summarized as

$$u_l^s = \frac{1}{1-\alpha} p^s c_N^s u_{c_T^s}, \qquad \text{for } s \in \{e, u\} \tag{75}$$

$$u_{c_T^e} = u_{c_T^u}(1+\psi), \tag{76}$$

$$u_{\mathrm{I}^s} = p^s c_N^s u_{c_T^s} - \frac{u_{d^s}}{\Psi^d\left(Q^{g,s}\right)}, \qquad \text{for } s \in \{e, u\} \tag{77}$$

$$u_{c_T^e} = (1+r)\mathbb{E}\left\{\beta u'_{c_T^e}[1+\psi'(1-n')] \mid \theta\right\}. \tag{78}$$

TABLE 7
Calibration of the Financial Frictions Economy

Target	Value	Parameter	Value
Share of tradables, $\frac{F_T^*}{Y^*}$	0.3	ω	0.93
Unemployment rate, U^*	7%	λ	0.05
Monthly job finding rate	45%	ν^e	0.67
Occupancy rate, $\frac{C_N^*}{F_N^*}$	0.81	ν^g	0.81
Capital to output ratio, $\frac{K^*}{Y^*}$	2.75	δ	0.007
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
Vacancy posting to output ratio	0.037	θ_N	0.67
Financial cost to output ratio	0.01	ψ	0.28
Units Parameters			
Output, Y^*	1	z_N	0.45
Relative price of nontradables, p^*	1	z_T	0.52
Market tightness in labor markets, $\frac{U^*}{V^*}$	1	κ	0.53
Market tightness in goods markets, D^*	1	ξ	0.02

TABLE 8
Baseline and Financial Friction Economies with Constant Labor Share

Model Economy	$\widehat{\beta}$	Employment	TFP	Consumption	Cost/Output
Baseline + constant labor share	0.85	-0.51	-0.67	-3.75	—
Multiple nontradable goods markets	1.15	-0.53	-0.67	-3.72	1.36

We calibrate ψ such that the steady-state financial cost $\psi(1-n)\mathrm{T}_r$ is 1% of output, although what matters the size of the shocks. We assume that ψ follows an AR(1) process with persistence of 0.95. The realization the shock results in a 1% output drop.

To see how a shock to ψ is related to a shock to β, we can log-linearize the Euler equation (78) as

$$\widehat{u}_{c^e_T,t} = \widehat{u}_{c^e_T,t+1} + \frac{\psi^*(1-n^*)}{1+\psi^*(1-n^*)}\widehat{\psi}_{t+1} - \frac{\psi^* n^*}{1+\psi^*(1-n^*)}\widehat{n}_{t+1}, \tag{79}$$

where ψ^* and n^* are their steady-state values. Define $\widehat{\beta}$ as the wedge between the intertemporal marginal utilities of consumption today and tomorrow, $\widehat{\beta} = \frac{\psi^*(1-n^*)}{1+\psi^*(1-n^*)}\widehat{\psi}_{t+1} - \frac{\psi^* n^*}{1+\psi^*(1-n^*)}\widehat{n}_{t+1}$. Recall that in the baseline economy with the discount factor shock, the log-linearized Euler equation is

$$\widehat{u}_{c_T,t} = \widehat{u}_{c_T,t+1} + \tau_t, \tag{80}$$

with $\widehat{\beta} = \tau$. Note how the effect of shock to ψ is similar to a shock to β. We then compare the implied $\widehat{\beta}$ with the shock to β in the baseline economy. We adopt a wage determination protocol that permits a constant labor share.[17]

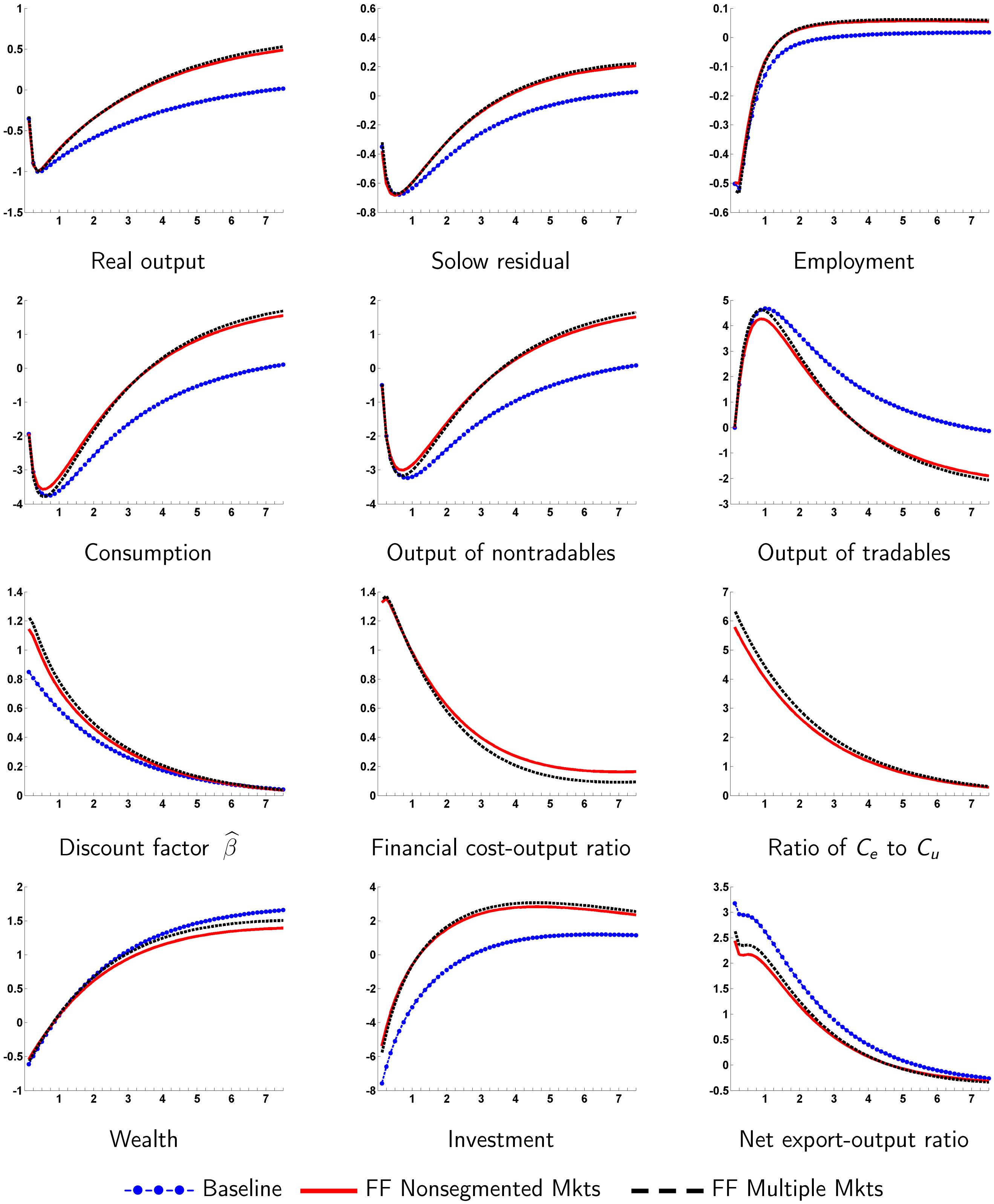
After a shock to ψ, agents reduce both the amount of consumption of each variety and the number of varieties. The unemployed reduce their shopping effort less than the employed, but their number of varieties decreases more because of a lower probability of finding a location.

The economy (it has the same exogenous parameters as the baseline and its ts calibration is described in Table 7) displays similar behavior to a version of the baseline economy where the wage determination mechanism implies constant labor share as can be seen in Figure 7 (which also shows the behavior of the economy with financial frictions and nonsegmented markets) and Table 8. The implied discount rate, $\widehat{\beta}$, in the financial frictions economy is 1.15% larger than β which compares to an increase of 0.85% in the corresponding baseline economy. The shock induces an increase in the financial cost to output ratio of 34%.

As we can see in Figure 7 the main difference between the financial frictions economy and the corresponding version of the baseline is that the former recovers faster and has a bit less reallocation of resources than the latter. As such, net exports go up to 2.5% of GDP, not 3%, and the increase

[17] We do not use Nash bargaining because after a ψ shock, one additional employed worker becomes much more valuable to the household, which greatly weakens the household's bargaining power and leads to an implausible decrease of wages.

Figure 7
Impulse Responses in the Baseline and Financial Friction Economies



in total wealth is about 1.3% and slowly disappears as the financial frictions return to normal. In other respects the financial friction economy behaves like the baseline. We also see that both financial friction economies (with and without segmented markets) behave almost identically.

11 Conclusion

In this paper, we generated demand-induced recessions in an otherwise standard neoclassical growth model. The two necessary ingredients are (1) adjustment costs that make it difficult for the economy to expand the tradable sector by reallocating factors of production from nontradables to tradables, and (2) 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 the goods markets, where increases in consumers' search efforts enable the economy to operate at a higher capacity (an extension of Bai, Ríos-Rull, and Storesletten (2011)). Consequently, reductions in household consumption reduce measured TFP. This feature is quantitatively important: its presence amplifies by two and a half times 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.

References

Aguiar, M., and E. Hurst (2005): "Consumption versus Expenditure," *Journal of Political Economy*, 113(5), 919–948.

——— (2007): "Life-Cycle Prices and Production," *American Economic Review*, 97(5), 1533–1559.

Aguiar, M. A., E. Hurst, and L. Karabarbounis (2013): "Time Use During the Great Recession," Forthcoming, *American Economic Review*.

Alessandria, G. (2009): "Consumer Search, Price Dispersion, and International Relative Price Fluctuations," *International Economic Review*, 50(3), 803–829.

Alessandria, G., S. Pratap, and V. Yue (2013): "Export Dynamics in Large Devaluations," mimeo.

Bai, Y., J.-V. Ríos-Rull, and K. Storesletten (2011): "Demand Shocks as Productivity Shocks," working paper, Federal Reserve Bank of Minneapolis.

Basu, S., and J. Fernald (1997): "Returns to Scale in U.S. Production: Estimates and Implications," *Journal of Political Economy*, 105(2), 249–283.

Bianchi, J. (2011): "Overborrowing and Systemic Externalities in the Business Cycle," *American Economic Review*, 101(7), 3400–3426.

Choi, S., and J.-V. Ríos-Rull (2008): "Understanding the Dynamics of Labor Share: The Role of Noncompetitive Factor Prices," mimeo.

Christiano, L., M. Eichenbaum, and C. Evans (2005): "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy*, 113(1), 1–45.

Christiano, L., M. Eichenbaum, and S. Rebelo (2011): "When Is the Government Spending Multiplier Large?," *Journal of Political Economy*, 119(1), 78–121.

Corrado, C., and J. Mattey (1997): "Capacity Utilization," *Journal of Economic Perspectives*, 11(1), 151–167.

Correia, I., E. Farhi, J. P. Nicolini, and P. Teles (2013): "Unconventional Fiscal Policy at the Zero Bound," *American Economic Review*, 103(4), 1171–1211.

Eggertsson, G. B. (2011): "What Fiscal Policy Is Effective at Zero Interest Rates?," in *NBER Macroeconomics Annual*, 25, 59-112, Chicago: University of Chicago Press.

Eggertsson, G. B., and P. Krugman (2012): "Debt, Deleveraging, and the Liquidity Trap: A Fisher-Minsky-Koo Approach," *Quarterly Journal of Economics*, 127(3), 1469–1513.

Farhi, E., and I. Werning (2012): "Fiscal Unions," working paper, MIT Department of Economics.

Gertler, M., and A. Trigari (2009): "Unemployment Fluctuations with Staggered Nash Wage Bargaining," *Journal of Political Economy*, 117(1), 38–86.

Greenwood, J., Z. Hercowitz, and G. Huffman (1988): "Investment, Capacity Utilization, and the Real Business Cycle," *American Economic Review*, 78(3), 402–418.

Guerrieri, V., and G. Lorenzoni (2011): "Credit Crises, Precautionary Savings, and the Liquidity Trap," NBER Working Paper 17583.

Hagedorn, M., and I. Manovskii (2008): "The Cyclical Behavior of Equilibrium Unemployment and Vacancies Revisited," *American Economic Review*, 98(4), 1692–1706.

Hall, R. (2005): "Employment Fluctuations with Equilibrium Wage Stickiness," *American Economic Review*, 95(1), 50–65.

Heathcote, J., and F. Perri (2002): "Financial Autarky and International Business Cycles," *Journal of Monetary Economics*, 49(3), 601–627.

——— (2012): "Wealth and Volatility," mimeo.

Jackson, L. F. (1984): "Hierarchic Demand and the Engel Curve for Variety," *The Review of Economics and Statistics*, 66(1), 8–15.

Kaplan, G., and G. Menzio (2013): "Shopping Externalities and Self-Fulfilling Unemployment Fluctuations," NBER Working Paper 18777.

Kehoe, T. J., and K. J. Ruhl (2009): "Sudden Stops, Sectoral Reallocations, and the Real Exchange Rate," *Journal of Development Economics*, 89(2), 235–249.

Krusell, P., T. Mukoyama, and A. Şahin (2010): "Labour-Market Matching with Precautionary Savings and Aggregate Fluctuations," *Review of Economic Studies*, 77(4), 1477–1507.

Li, N. (2013): "An Engel Curve for Variety," working paper, University of Toronto.

Mendoza, E. G. (2001): "Credit, Prices, and Crashes: Business Cycles with a Sudden Stop," NBER Working Paper 8338.

Mendoza, E. G., and V. Z. Yue (2012): "A General Equilibrium Model of Sovereign Default and Business Cycles," *Quarterly Journal of Economics*, 127(2), 889–946.

Merz, M. (1995): "Search in the Labor Market and the Real Business Cycle," *Journal of Monetary Economics*, 36(2), 269–300.

Mian, A., and A. Sufi (2010): "The Great Recession: Lessons from Microeconomic Data," *American Economic Review*, 100(2), 51–56.

——— (2012): "What Explains High Unemployment? The Aggregate Demand Channel," unpublished manuscript, Booth School of Business.

Midrigan, V., and T. Philippon (2011): "Household Leverage and the Recession," Working Paper FIN-11-038, New York University.

Nakajima, M. (2012): "Business Cycles in the Equilibrium Model of Labor Market Search and Self-Insurance," *International Economic Review*, 53(2), 399–432.

Rendahl, P. (2012): "Fiscal Policy in an Unemployment Crisis," working paper, University of Cambridge.

Schmitt-Grohe, S., and M. Uribe (2011): "Pegs and Pain," NBER Working Paper 16847.

Schmitt-Grohe, S., and M. Uribe (2012): "The Making of a Great Contraction with a Liquidity Trap and a Jobless Recovery," NBER Working Paper 18544.

Shimer, R. (2005): "The Cyclical Behavior of Equilibrium Unemployment and Vacancies," *American Economic Review*, 95(1), 25–49.

Shimer, R. (2012): "Wage Rigidities and Jobless Recoveries," *Journal of Monetary Economics*, 59 (Supplement), 565–577.

Silva, J. I., and M. Toledo (2009): "The Unemployment Volatility Puzzle: The Role of Matching Costs Revisited," mimeo.

Appendix (Not for Publication)

A Simplification of the Household's Problem

The original problem for households is

$$V(S,b,n) = \max_{c_{N,i},c_T,\mathrm{I}_N,d} u(c_A,d,n) + \beta\,\mathbb{E}\left\{V(S',b',n') \mid \theta\right\}, \tag{A.1}$$

subject to

$$\int_0^{\mathrm{I}} p_i(S)\; c_{N,i}\; di + c_T + b', = (1+r)b + w(S)n + \pi_N(S) + \pi_T(S), \tag{A.2}$$

$$\mathrm{I} = \Psi^d[Q^g(S)]\; d, \tag{A.3}$$

$$n' = (1-\lambda)n + \Phi^w[Q^e(S)](1-n), \tag{A.4}$$

$$S' = G(S). \tag{A.5}$$

This problem involves choosing how much to consume of each variety, $c_{N,i}$. Instead, we can solve a two-stage problem. In the first stage, we choose the number of varieties, the expenditures in nontradable consumption, and the expenditures in tradable consumption. In the second stage, we solve how much $c_{N.i}$ to purchase of each variety i given the number of varieties I and the total expenditure Z of nontradable consumption. We can rewrite the second stage as written as

$$\max_{c_i}\left[\int_0^{\mathrm{I}} c_i^{\frac{1}{\rho}}\right]^{\rho}, \tag{A.6}$$

subject to

$$\int_0^{\mathrm{I}} p_i c_{N,i} \leq Z. \tag{A.7}$$

The first-order condition gives

$$c_{N,i} = c_{N,j}\left(\frac{p_i}{p_j}\right)^{\frac{\rho}{1-\rho}}. \tag{A.8}$$

Define the consumption bundle c_N and the price index p as

$$c_N = \left[\frac{1}{\mathrm{I}} \int_0^{\mathrm{I}} c_{N,i}^{\frac{1}{\rho}} \right]^{\rho}, \tag{A.9}$$

$$p = \left[\frac{1}{\mathrm{I}} \int_0^{\mathrm{I}} p_i^{\frac{1}{1-\rho}} \right]^{1-\rho}. \tag{A.10}$$

Substituting equation (A.8) into the budget constraint gives

$$c_{N.i} = \left(\frac{p_i}{p} \right)^{\frac{\rho}{1-\rho}} \frac{Z}{p\mathrm{I}}. \tag{A.11}$$

Combining equation (A.11) and the definition of c_N leads to

$$\int_0^{\mathrm{I}} p_i c_{N,i} = p\mathrm{I} c_N. \tag{A.12}$$

It is then straightforward to derive the demand schedule for each variety:

$$c_{N,i} = \left(\frac{p_i}{p} \right)^{\frac{\rho}{1-\rho}} c_N', \tag{A.13}$$

and we only need to keep track of c_N and I in the utility function:

$$\left[\int_0^{\mathrm{I}} c_{N,i}^{\frac{1}{\rho}} \right]^{\rho} = c_N \mathrm{I}^{\rho}. \tag{A.14}$$

Note that under the assumption that search in the goods market is undirected, the price index p is independent of the number of varieties I. All the derivations above do not rely on the assumption that all prices for nontradables are equal, even though this is indeed the case in equilibrium. In the end, we can rewrite the household's problem as

$$V(S, b, n) = \max_{c_N, c_T, \mathrm{I}_N, d} u(c_A, d, n) + \beta\, \mathbb{E} \left\{ V(S', b', n') \mid \theta \right\}, \tag{A.15}$$

subject to

$$c_A = \left[\omega \left(c_N \mathrm{I}_N^{\rho}\right)^{-\eta} + (1-\omega)\, c_T^{-\eta}\right]^{-\frac{1}{\eta}}, \tag{A.16}$$

$$p(S)c_N\mathrm{I} + c_T + b' = (1+r)b + w(S)n + \pi_N(S) + \pi_T(S), \tag{A.17}$$

$$\mathrm{I} = \Psi^d[Q^g(S)]\, d, \tag{A.18}$$

$$n' = (1-\lambda)n + \Phi^w[Q^e(S)](1-n), \tag{A.19}$$

$$S' = G(S). \tag{A.20}$$

B Discussion of GHH Preferences

We choose GHH preferences between consumption and the shopping disutility to allow the number of varieties of nontradable goods to be a normal good. Consider the following simplified static problem without tradable goods:

$$\max_{c,\mathrm{I},d} \quad \frac{1}{1-\sigma}\left(c\mathrm{I}^{\rho} - d\right)^{1-\sigma} \tag{B.1}$$

subject to

$$c\mathrm{I} = E, \tag{B.2}$$

$$\mathrm{I} = d\Psi^d(Q), \tag{B.3}$$

where E is total income and the price is normalized to 1. After substituting the constraints into the objective function and defining $A = (\Psi^d(Q))^{-1}$, the original problem can be rewritten as

$$\max_{\mathrm{I}} \quad E\mathrm{I}^{\rho-1} - A\mathrm{I}. \tag{B.4}$$

The first-order condition gives

$$(\rho-1)E\mathrm{I}^{\rho-2} = A. \tag{B.5}$$

The solution of the problem is

$$\mathrm{I}^* = E^{\frac{1}{2-\rho}}(\rho-1)^{\frac{1}{2-\rho}}A^{\frac{-1}{2-\rho}}. \tag{B.6}$$

Note that I^* is increasing in E if $2-\rho > 0$. Since typical estimates of ρ are between 1 and 1.5, this condition is not restrictive. The number of varieties is a normal good.

C Alternatives to the Baseline Economy

Baseline Economy Minus Goods Market Frictions The first alternative model economy that we consider has frictions in the labor market but not in the goods market. Households cannot choose their labor. The period utility function for the household is $u(c,n) = \frac{c^{1-\sigma}}{1-\sigma} - \varsigma n$. Here, the consumers have neither a shopping choice nor a labor choice (no need to shop, and they work as much as they can). The problem of the household is

$$V(S,b,n) \;=\; \max_{c_N,c_T,b} u(c,n) + \mathbb{E}\{\beta V(S',b',n')|\theta\}, \tag{C.1}$$

$$\text{subject to} \qquad p(S)c_N + c_T + b' = (1+r)b + w(S)n + \pi_N(S) + \pi_T(S), \tag{C.2}$$

$$n' = (1-\lambda)n + \Phi^w[Q^e(S)](1-n), \tag{C.3}$$

$$S' = G(S), \tag{C.4}$$

where $\left[\omega\,(c_N)^{\frac{\eta-1}{\eta}} + (1-\omega)c_T^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$. Although the problem of the firms in the tradable goods sector is the same as in the baseline economy, firms in the nontradable goods sector solve

$$\Omega^N(S,k,n) \;=\; \max_{p_i,i,v} p_i C(p_i,S) - w(S)n - i - v\kappa + \mathbb{E}\left\{\frac{\Omega^N(S',k',n')}{1+r} \mid \theta\right\}, \tag{C.5}$$

$$\text{subject to} \qquad C(p_i^c,S) \le F^N(k,n), \tag{C.6}$$

$$k' = (1-\delta)k + i - \phi^N(k,i), \tag{C.7}$$

$$n' = (1-\lambda)n + \Phi^f[Q^e(S)]v, \tag{C.8}$$

$$S' = G(S). \tag{C.9}$$

Frictionless Economy The frictionless economy we considered is a two-sector small open economy without frictions in either the labor market or the goods market. Households still value varieties but do not need to search to find them. Therefore, $\mathrm{I} = 1$ and aggregated nontradable consumption is $c_N = \left[\int_0^1 c_{N,i}^{\frac{1}{\rho}} di\right]^{\rho}$, with the price index defined as $p = \left[\int_0^1 p_i^{\frac{1}{1-\rho}} di\right]^{1-\rho}$. Households choose how much labor to supply, firms are able to immediately adjust labor input and the wage rate clears the market. We assume a standard additively separable utility function $u(c,n) = \frac{c^{1-\sigma}}{1-\sigma} - \xi_n \frac{n^{1+\gamma}}{1+\gamma}$.

The problem of households is

$$V(S,b) \;=\; \max_{c_N, c_T, n, b'} u\left(c,n\right) + \beta \mathbb{E}\{V(S',b') \mid \theta\}, \tag{C.10}$$

$$\text{subject to} \qquad p(S)c_N + c_T + b' = (1+r)b + w(S)n + \pi_N(S) + \pi_T(S), \tag{C.11}$$

$$S' = G(S), \tag{C.12}$$

where $\left[\omega\left(c_N\right)^{\frac{\eta-1}{\eta}} + (1-\omega)c_T^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$. Unlike in the baseline economy where n evolves exogenously, here n is a choice variable for households.

Firms in the nontradable goods sector solve the following problem:

$$\Omega^N(S,k) \;=\; \max_{p_i, i, n} p_i C(p_i, S) - w(S)n - i + \mathbb{E}\left\{\frac{\Omega^N(S',k')}{1+r} \mid \theta\right\}, \tag{C.13}$$

$$\text{subject to} \qquad C(p_i^c, S) \leq F^N(k,n), \tag{C.14}$$

$$k' = (1-\delta)k + i - \phi^N(k,i), \tag{C.15}$$

$$S' = G(S). \tag{C.16}$$

Firms in the tradable goods sector solve the following problem:

$$\Omega^T(S,k,n^-) \;=\; \max_{i,n} F^T(k,n) - w(S)n_T - i_T - \phi^{T,n}(n,n^-) + \mathbb{E}\left\{\frac{\Omega^T(S',k',n)}{1+r} \mid \theta\right\}, \tag{C.17}$$

$$\text{subject to} \qquad k' = (1-\delta)k + i - \phi^{T,k}(k,i), \tag{C.18}$$

$$S' = G(S). \tag{C.19}$$

Frictionless Economy Plus Goods Market Friction This model economy has a competitive labor market and frictions in the goods market; that is, households need to search for varieties, but they can choose how much to work. The period utility function for the household is $u(c,d,n) =$

$\frac{1}{1-\sigma}\left(c-\xi_d d\right)^{1-\sigma}-\xi_n\frac{n^{1+\gamma}}{1+\gamma}$. The problem of households is

$$V(S,b,n) \;=\; \max_{c_N,c_T,\mathrm{I}_N,d} u(c,d,n)+\mathbb{E}\{\beta V(S',b',n')|\theta\}, \tag{C.20}$$

subject to

$$p(S)c_N\mathrm{I}+c_T+b'=(1+r)b+w(S)n+\pi_N(S)+\pi_T(S), \tag{C.21}$$
$$\mathrm{I}_N=d\Psi^d[Q^g(S)], \tag{C.22}$$
$$n'=(1-\lambda)n+\Phi^w[Q^e(S)](1-n), \tag{C.23}$$
$$S'=G(S). \tag{C.24}$$

where $\left[\omega\left(c_N\mathrm{I}^{\rho}\right)^{\frac{\eta-1}{\eta}}+(1-\omega)c_T^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$.

The problem of the firms in the nontradable goods sector is

$$\Omega^N(S,k) \;=\; \max_{p_i,i,n}\Psi^f[Q^g(s)]p_iC(p_i,S)-w(S)n-i+\mathbb{E}\left\{\frac{\Omega^N(S',k')}{1+r}\mid\theta\right\}, \tag{C.25}$$

subject to

$$C(p_i^c,S)\leq F^N(k,n), \tag{C.26}$$
$$k'=(1-\delta)k+i-\phi^N(k,i), \tag{C.27}$$
$$S'=G(S). \tag{C.28}$$

The problem of the firms in the tradable goods sector is the same as in the frictionless economy.

Economy with Staggered Wage Contracts Assume that, every period, a fraction θ_w of employed workers have the chance to renegotiate their wages with firms and denote the economy-wide average wage rate by $w(S)$ and the newly negotiated wage rate by $\widetilde{w}(S)$. The evolution of the average wage rate is as follows:

$$w(S)=(1-\theta_w)w(S^-)+\theta_w\widetilde{w}(S), \tag{C.29}$$

where $w(S^-)$ denotes the average wage rate last period. Note that equation (C.29) implies that those who just became employed negotiate their wage with probability θ_w. Otherwise, they receive last period's average wage rate $w(S^-)$.

For households and firms, only the average wage rate $w(S)$ matters, and therefore, their problems are unchanged. The difference lies in the process of Nash bargaining. Under wage stickiness, the marginal value of a worker for the household with an average wage differs from the value of a worker with a newly set wage. Let $\widetilde{V}(w, S)$ be the value of a worker for the household if they just bargain the wage rate at w:

$$\widetilde{V}(w, S) = wu_{c_T}(S) - \varsigma + (1-\lambda)\mathbb{E}\left\{\beta(1-\theta_w)\widetilde{V}(w, S') + \beta\theta_w\widetilde{V}(\widetilde{w}(S'), S') \mid \theta\right\} \\ - \Phi^w[Q^e(S)]\mathbb{E}\{\beta V_n(S') \mid \theta\}. \quad \text{(C.30)}$$

Notice that the wage rate may be the same next period with probability θ_w or may become the newly set wage $\widetilde{w}(S')$. The value of a worker with a newly set wage rate w for firms in the nontradable sector is

$$\widetilde{J}^N(w, S) = \Psi^f[Q^g(S)]p(S)F_n^N(S)\frac{1}{\rho} - w + \frac{(1-\lambda)}{1+r}\mathbb{E}\{(1-\theta_w)\widetilde{J}^N(w, S') + \theta_w\widetilde{J}^N(\widetilde{w}(S'), S') \mid \theta\}, \quad \text{(C.31)}$$

and for the firms in the tradable sector it is

$$\widetilde{J}^T(w, S) = F_n^T(S) - w - \phi_n^{T,n}(S) + \frac{(1-\lambda)}{1+r}\mathbb{E}\{(1-\theta_w)\widetilde{J}^T(w, S') + \theta_w\widetilde{J}^T(\widetilde{w}(S'), S') \mid \theta\}. \quad \text{(C.32)}$$

As in the baseline economy, we maintain the assumption that the value of a worker for firms is a weighted value of the evaluation of the worker by the firms with weights given by the employment share of each sector. Recall that $\chi(S) = \frac{n_N}{n_N + n_T}$ is the employment share of the nontradable sector. Then, the Nash bargaining problem is

$$\widetilde{w}(S) = \max_w \left[\widetilde{V}(w, S)\right]^{\varphi}\left[\chi(S)\widetilde{J}^N(w, S) + (1-\chi(S))\widetilde{J}_n^T(w, S)\right]^{1-\varphi}. \quad \text{(C.33)}$$

Taking the derivative with respect to w yields the first-order condition

$$\varphi\widetilde{V}_w(w, S)\left[\chi(S)\widetilde{J}^N(w, S) + (1-\chi(S))\widetilde{J}^T(w, S)\right] = (1-\varphi)\frac{1+r}{r+\lambda+\theta_w-\lambda\theta_w}\widetilde{V}(w, S), \quad \text{(C.34)}$$

where $V_w(w, S)$ is the discounted sum of marginal utility by increasing the wage rate by one unit:

$$\widetilde{V}_w(w, S) = u_{c_T}(S) + \mathbb{E}\{\beta(1-\theta_w)(1-\lambda)\widetilde{V}_w(w, S') \mid \theta\}. \quad \text{(C.35)}$$

Calibration, Tables, and Figures of Alternative Model Economies

TABLE 9
Exogenously Determined Parameters
in the Economy with Labor Frictions but without Goods Markets Frictions

Parameter	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 bw tradables and nontradables, η	0.83
Price markup, ρ	1.05

TABLE 10
Steady-State Targets and Associated Parameters
in the Economy with Labor Frictions but without Goods Markets Frictions

Target	Value	Parameter	Value
Share of tradables, $\frac{F_T^*}{Y^*}$	0.3	ω	0.91
Unemployment rate, U^*	7%	λ	0.05
Monthly job finding rate	45%	ν^e	0.67
Capital to output ratio, $\frac{K^*}{Y^*}$	2.75	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
Vacancy posting to output ratio	0.037	κ	0.53
Value of leisure to wage ratio	0.35	φ	0.42
Units Parameters			
Output, Y^*	1	z_N	0.36
Relative price of nontradables, p^*	1	z_T	0.52
Market tightness in labor markets, $\frac{U^*}{V^*}$	1	ς	0.53

Table 11

Exogenously Determined Parameters in the Frictionless Economy

Parameter	Value
Risk aversion, σ	2.0
Annual rate of return, β	$\frac{1}{\beta^8} - 1 = 4\%$
Elasticity of substitution bw tradables and nontradables, η	0.83
Working Frisch elasticity, γ	1.50
Price markup, ρ	1.05

Table 12

Steady-State Targets and Associated Parameters in the Frictionless Economy

Target	Value	Parameter	Value
Share of tradables, $\frac{F_T^*}{Y^*}$	0.3	ω	0.90
Fraction of time working, n^*	0.3	ξ_n	26.66
Capital to output ratio, $\frac{K^*}{Y^*}$	2.75	δ	0.009
Labor share in nontradables	0.6	θ_N	0.63
Labor share in tradables	0.6	θ_T^N	0.60
Equal role of capital and land in tradables,	$2\theta_T^K + \theta_T^N = 1$	θ_T^K	0.20
Units Parameters			
Output, Y^*	1	z_N	0.64
Relative price of nontradables, p^*	1	z_T	0.95

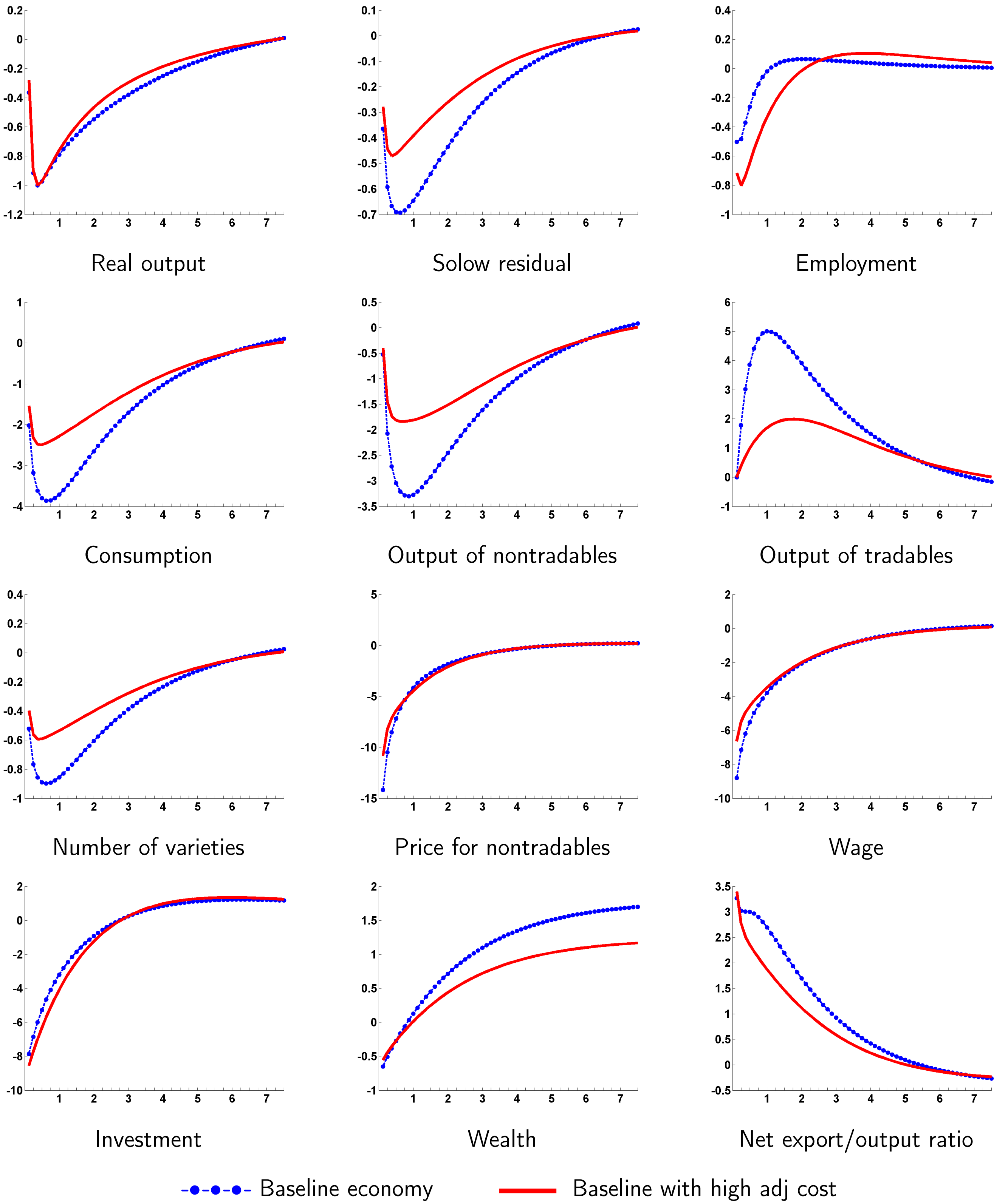
Table 13
Exogenously Determined Parameters
in the Economy with Goods Frictions but without Labor Frictions

Parameter	Value
Risk aversion, σ	2.0
Annual rate of return, β	$\frac{1}{\beta^8} - 1 = 4\%$
Elasticity of substitution bw tradables and nontradables, η	0.83
Working Frisch elasticity, γ	1.50
Price markup, ρ	1.05

Table 14
Steady-State Targets and Associated Parameters
in the Economy with Goods Frictions but without Labor Frictions

Target	Value	Parameter	Value
Share of tradables, $\frac{F_T^*}{Y^*}$	0.3	ω	0.91
Fraction of time working, n^*	0.3	ξ_n	27.89
Occupancy rate, $\frac{C_N^*}{F_N^*}$	.81	ν^g	0.81
Capital to output ratio, $\frac{K^*}{Y^*}$	2.75	δ	0.009
Labor share in nontradables	0.6	θ_N	0.63
Labor share in tradables	0.6	θ_T^N	0.60
Equal role of capital and land in tradables,	$2\theta_T^K + \theta_T^N = 1$	θ_T^K	0.20
Units Parameters			
Output, Y^*	1	z_N	0.80
Relative price of nontradables, p^*	1	z_T	0.95
Market tightness in goods markets, D^*	1	ξ_d	0.02

FIGURE 8
Impulse Responses in the Baseline and High Adjustment Cost Economies



Other Alternative Calibration Targets

Table 15 displays the main properties of the recession in various alternative economies. A higher elasticity of substitution between nontradables and tradables allows households to greatly reduce their consumption of tradables without reducing much of their nontradables, which makes recessions harder to create. The required shock increases by 5% when the elasticity of substitution increases about 40%. We conclude that the differences are small.

For the same reduction in employment as in the baseline economy, a higher labor market matching elasticity μ, makes hiring a new worker cheaper. The total reallocation costs are also cheaper. As a result, to get the same size recession, a 20% larger initial shock is needed.

The role of goods market matching elasticity α is straightforward. For the same decrease in aggregate search effort, D, a higher matching elasticity α leads to a larger decline in the probability of meeting customers. Therefore, the Solow residual and aggregate output decrease further. The size of the shock needed to obtain a 1% recession is 20% smaller when α changes from 0.22 to 0.30.

A lower elasticity of substitution between nontradable goods ($\frac{\rho}{\rho-1}$) increases the elasticity of the number of varieties I with respect to consumption per variety, c_N. In other words, with the same reduction in c_N, an economy with higher ρ will have a larger drop in I. As can be seen from Table 15, the elasticity of I with respect to c_N is largest when $\rho = 1.08$, corresponding to a larger drop in the Solow residual and a smaller required shock to patience.

As we decrease vacancy costs, the required shock is smaller and the wage rate drop less. The main reason for this change is that workers' bargaining power increases as vacancy costs decrease in order to calibrate to a constant labor share. The issue of how to model the bargaining process between workers and firms is still in debate in the labor market search literature.[18] Most studies focus on the effect of productivity shocks on labor market volatility. Higher bargaining power for workers implies large wage volatility and low employment volatility. However, this argument cannot be carried over into the current environment. In this paper, the recession originates from changes in the willingness to enjoy consumption and leisure today versus tomorrow. These changes result in increased volatility of employment when workers' weight is larger, which in turn implies that the required size of the shock is much lower.

[18]See Shimer (2005) and Hagedorn and Manovskii (2008).

Table 15
Alternative Calibration Targets

Elasticity of substitution between nontradable and tradable

Parameter	Pref Shock	Employment	TFP	Tradable Consumption
$\eta = 0.83$	0.88	-0.50	-0.69	-12.33
$\eta = 1.20$	0.93	-0.49	-0.70	-17.17
$\eta = 0.60$	0.84	-0.50	-0.68	-9.17

Labor market matching elasticity

Parameter	Pref Shock	Employment	TFP	Elast of N_N wrt N_T
$\mu = 0.50$	0.88	-0.50	-0.69	-68.95
$\mu = 0.70$	1.05	-0.31	-0.80	-56.27
$\mu = 0.40$	0.79	-0.58	-0.64	-76.97

Goods market matching elasticity

Parameter	Pref Shock	Employment	TFP	Number of varieties
$\alpha = 0.22$	0.88	-0.50	-0.69	-0.89
$\alpha = 0.30$	0.70	-0.38	-0.77	-1.03
$\alpha = 0.10$	1.32	-0.78	-0.48	-0.55

Elasticity of substitution between nontradable goods

Parameter	Pref Shock	Employment	TFP	Elast of I wrt c_N
$\rho = 1.05$	0.88	-0.50	-0.69	58.55
$\rho = 1.08$	0.83	-0.46	-0.72	62.49
$\rho = 1.02$	0.93	-0.54	-0.65	53.88

Vacancy costs

Vacancy cost	Pref Shock	Employment	TFP	Wage rate
3.74%	0.88	-0.50	-0.69	-8.79
2.00%	0.72	-0.66	-0.58	-7.40
1.00%	0.54	-0.84	-0.47	-5.66

D Financial Frictions with Nonsegmented Goods Markets

In the financial frictions economy with nonsegmented goods markets, financial frictions occur between shopping and consuming, meaning that the prices faced and the number of consumption varieties used by both employed and unemployed workers are the same. In other words, shoppers first buy a certain amount of goods at each firm and then distribute the goods to the two groups of workers. The amount of goods bought at each location is simply $nc_N^e + (1-n)c_N^u$, where e and u stand for employed and unemployed, respectively. In the absence of financial frictions, the household would equate consumption between employed and unemployed workers. Financial frictions induce the household to provide different amounts of consumption. The problem of the household is now

$$V(S,b,n) = \max_{c_N^e, c_T^e, c_N^u, c_T^u, \mathrm{I}, d} nu(c_A^e, d, 1) + (1-n)u(c_A^u, d, 0) + \beta\, \mathbb{E}\left\{V(S', b', n') \mid \theta\right\}, \tag{D.1}$$

subject to

$$\begin{aligned} n[p(S)\mathrm{I}c_N^e + c_T^e]+ & \\ (1-n)[p(S)\mathrm{I}c_N^u + c_T^u] &= (1+r)b + w(S)n + \pi_N(S) + \pi_T(S) - \psi(1-n)\mathrm{T}_r - b', & \text{(D.2)}\\ \mathrm{T}_r &= p(S)\mathrm{I}c_N^u + c_T^u - [(1+r)b + \pi_N(S) + \pi_T(S)], & \text{(D.3)}\\ \mathrm{I} &= \Psi^d[Q^g(S)]\, d, & \text{(D.4)}\\ n' &= (1-\lambda)n + \Phi^w[Q^e(S)](1-n), & \text{(D.5)}\\ S' &= G(S). & \text{(D.6)} \end{aligned}$$

The total consumption expenditures of each unemployed worker are $p(S)\mathrm{I}c_N^u + c_T^u$, and the financial assets available to each worker are bond holdings plus the profits from firms $(1+r)b + \pi_N(S) + \pi_T(S)$. In the budget constraint, the transfer to an unemployed worker is T_r, the difference between consumption and per agent financial assets, and the financial costs of this transfer are $\psi(1-n)\mathrm{T}_r$. When the household accumulates more savings, the financial costs to achieve the same consumption for the unemployed are smaller. The first-order conditions are

$$u_{c_N^e} = p(S)\mathrm{I}u_{c_T^e}, \tag{D.7}$$

$$u_{c_N^u} = p(S)\mathrm{I}u_{c_T^u}, \tag{D.8}$$

$$u_{c_T^e} = u_{c_T^u}(1+\psi), \tag{D.9}$$

$$n\left[u_{\mathrm{I}}^e - p(S)c_N^e u_{c_T^e} + \frac{u_d^e}{\Psi^d[Q^g(S)]}\right] = -(1-n)\left[u_{\mathrm{I}}^u - p(S)c_N^u u_{c_T^u} + \frac{u_d^u}{\Psi^d[Q^g(S)]}\right], \tag{D.10}$$

$$u_{c_T^e} = (1+r)\mathbb{E}\left\{\beta u'_{c_T^e}[1+\psi'(1-n')] \mid \theta\right\}. \tag{D.11}$$

Equations (D.7) and (D.8) describe the optimality condition between tradables and nontradables. Equation (D.9) implies that unless financial costs are zero (i.e, $\psi = 0$), the consumption level of the employed will be higher than the unemployed. The inequality is increasing in ψ. In the baseline economy, the optimal choice of I equalizes the benefits of one variety and the cost of its associated shopping disutility. With two groups sharing the same number of varieties, the optimal I equalizes a weighted average of costs and benefits, with the weights given by the employment rate. Equation (D.11) is the Euler equation, which we write in terms of consumption of the employed. The problems of the firms are the same as in the baseline economy, except that aggregate demand is now $C_N(S) = n\ C_N^e(S) + (1-n)\ C_N^u(S)$.

We still assume that ψ follows an AR(1) process with persistence of 0.95 and the size of the shock is chosen to get a 1% real output drop. In the first two rows of Table 8, we compare the size of the shocks in terms of the explicit or implied proportional change in the discount factor. We use a version of the baseline economy with constant factor shares as well as the economies with financial shocks and constant factor shares. The value goes from 0.85% to 1.14%. The financial cost to output ratio goes from 1% in steady state to 1.33% after the shock to ψ. In terms of employment and the Solow residual, the financial friction economy is very similar to the baseline economy with shocks to the patience.

The exogenously determined parameters are the same as for the baseline economy, and we do not report them here.

TABLE 16
Steady-State Targets and Associated Parameters
in the Financial Shocks Economy with Nonsegmented Goods Markets

Target	Value	Parameter	Value
Share of tradables, $\frac{F_T^*}{Y^*}$	0.3	ω	0.91
Unemployment rate, U^*	7%	λ	0.05
Monthly job finding rate	45%	ν^e	0.67
Occupancy rate, $\frac{C_N^*}{F_N^*}$	0.81	ν^g	0.81
Capital to output ratio, $\frac{K^*}{Y^*}$	2.75	δ	0.007
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
Vacancy posting to output ratio	0.037	θ_N	0.67
Financial cost to output ratio	0.01	ψ	0.28
Units Parameters			
Output, Y^*	1	z_N	0.45
Relative price of nontradables, p^*	1	z_T	0.52
Market tightness in labor markets, $\frac{U^*}{V^*}$	1	κ	0.53
Market tightness in goods markets, D^*	1	ξ	0.02