Resurrecting the Role of the Product Market Wedge in Recessions

Mark Bils
University of Rochester and NBER

Peter J. Klenow
Stanford University and NBER

Benjamin A. Malin*
Federal Reserve Bank of Minneapolis

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Abstract

Employment and hours appear far more cyclical than dictated by the behavior of productivity and consumption. This puzzle has been called "the labor wedge" — a cyclical intratemporal wedge between the marginal product of labor and the marginal rate of substitution of consumption for leisure. The intratemporal wedge can be broken into a product market wedge (price markup) and a labor market wedge (wage markup). Based on the wages of employees, the literature has attributed the intratemporal wedge almost entirely to labor market distortions. Because employee wages may be smoothed versions of the true cyclical price of labor, we instead examine the self-employed and intermediate inputs, respectively. Looking at the past quarter century in the U.S., we find that price markup movements are at least as important as wage markup movements — including in the Great Recession and its aftermath. Thus sticky prices and other forms of countercyclical markups deserve a central place in business cycle research, alongside sticky wages and matching frictions.

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1. Introduction

Employment and hours are more cyclical than can be explained by real labor productivity under conventional preferences for consumption and leisure. See Hall (1997), Mulligan (2002), and Chari, Kehoe and McGrattan (2007), among others. This "labor wedge" — hereafter, the intratemporal wedge — could reflect either a gap between the marginal product and price of labor (i.e., a product market wedge), or a gap between the price of labor and the opportunity cost of supplying labor (i.e., a labor market wedge). The decomposition matters for both stabilization policy and understanding the nature of business cycles. Recently, a growing consensus argues the labor market wedge is key — see, e.g., Galí, Gertler, and Lopez-Salido (2007), Shimer (2009), Hall (2009), and Karabarbounis (2014a). This has helped drive an explosion of work on search, matching, and wage setting in the labor market.

The consensus that the intratemporal wedge reflects labor market distortions is based on measuring the price of labor using average hourly earnings. The gap between average hourly earnings and labor productivity is acyclical, suggesting price markup movements are not cyclical. But it is not clear whether the marginal cost of labor to firms is well-measured by average hourly earnings. Employee wages may not reflect the true marginal cost of labor to the firm. Wages may be smoothed versions of the shadow cost due to implicit contracting (e.g., for salaried workers). One obtains a very different picture of the cyclical price of labor using the wages of new hires, as measured by Pissarides (2009) and Haefke, Sonntag, and van Rens (2013), or from the user cost of labor, as measured by Kudlyak (2014).

In this paper, we seek evidence on cyclical distortions in the product market that does not rely on wage data for workers. First, we estimate the intratemporal wedge for the self-employed. If we observe significant cyclicality in the intratemporal wedge for the self-employed, we presume it cannot be ascribed to wage rigidities or other labor market frictions. Second, we estimate the product market wedge from intermediate inputs (energy, materials, and services). Intermediate prices should provide a truer measure of that input's cyclical price than do average hourly earnings for labor.

Our evidence is for the U.S. from 1987 onward. A benefit of using two distinct approaches is that they rely on different data sources. For the self-employed, we look at *household* data from the Current Population Survey and the Consumer Expenditure Survey, both conducted by the Bureau of Labor Statistics (BLS). For intermediates we use the BLS Multifactor Productivity Database covering 60 *industries*. Our consistent finding is that, contrary to the emerging consensus, product market distortions are at least as important as labor market distortions in recent recessions.

The cyclical product market wedge we estimate is compatible with firm sales being constrained in recessions by a (too high) sticky price. Given the wedge's strong persistence, it is also consistent with firms purposefully choosing a higher markup over marginal cost in recessions. As a recent example, Gilchrist, Schoenle, Sim, and Zakrajsek (2014) find that financially-constrained firms chose higher markups rather than investing in market share during the Great Recession. Any model where expanding production has a component of investment (e.g., learning-by-doing) should have similar implications. Additionally, the product market wedge could reflect greater uncertainty, or aversion to uncertainty, in recessions, e.g., as in Arellano, Bai, and Kehoe (2012).

Our study is related to several earlier efforts. Bils (1987), Rotemberg and Woodford (1999), Bils, Klenow and Malin (2013), and Nekarda and Ramey (2013) rely on measured earnings to estimate the marginal price of labor and thereby cyclicality of the markup. Other studies infer the cyclicality of price markups from the cyclicality of investment (Galeotti and Schiantarelli, 1998), final goods inventories (Bils and Kahn, 2000 and Kryvtsov and Midrigan, 2012), and advertising (Hall, 2014).

The paper proceeds as follows. Section 2 revisits the conventional intratemporal wedge decomposition using wages, doing so for both the extensive and intensive margins. Section 3 looks at the self-employed. Section 4 investigates intermediate input use. Section 5 relates our work to other efforts at measuring cyclicality of markups. Section 6 concludes.

2. The Aggregate Intratemporal Wedge

We begin by constructing the standard *representative-agent* intratemporal wedge (RAW), defined as the ratio of the marginal product of labor (mpn) to the tax-adjusted marginal rate of substitution of consumption for leisure (mrs). Shimer (2009) provides a thorough derivation of the RAW, starting from the maximization problems of a representative household and firm. Constructing the wedge requires assumptions on preferences and technology; our baseline case follows Hall (1997) and Galí, Gertler, and Lopez-Salido (2007). Production features a constant elasticity of output with respect to hours.[1] Preferences are separable in consumption and hours, and over time, with a constant intertemporal elasticity for consumption and a constant Frisch elasticity of labor supply.[2] These assumptions yield a log-linear intratemporal wedge:

$$\begin{aligned} RAW_t &\equiv \ln(mpn_t) + \ln(1-\tau_t) - \ln(mrs_t) \\ &= \ln\left(\frac{y_t}{n_t}\right) + \ln(1-\tau_t) - \left[\frac{1}{\sigma}\ln(c_t) + \frac{1}{\eta}\ln(n_t)\right], \end{aligned} \tag{1}$$

where $\frac{y_t}{n_t}$ is output per hour, c_t is nondurables and services consumption per adult equivalent, n_t is hours per capita, and $\tau_t \equiv \frac{\tau_t^c + \tau_t^n}{1+\tau_t^c}$ is a combination of average marginal tax rates on consumption and labor. See the Appendix for a precise description of all variables used.

[1] We later entertain CES production in capital, labor, and intermediate inputs.

[2] Nonseparable utility in consumption and leisure would not alter our results significantly. Shimer (2009) and Karabarbounis (2014a) found this as well. We find the same if we calibrate the nonseparability to how consumption responds to retirement (Aguiar and Hurst, 2013) or unemployment (Saporta-Eksten, 2014).

For our baseline case, we use an intertemporal elasticity of substitution (IES) of $\sigma = 0.5$ following Hall (2009), and a Frisch elasticity of labor supply of $\eta = 1.0$, based on Chang, Kim, Kwon, and Rogerson (2014). The latter argue, based on a heterogeneous-agent model with both intensive and extensive labor margins, that a representative-agent Frisch elasticity of 1 (or slightly higher) is reasonable.

To gauge the cyclicality of the RAW, we project it on real GDP and hours worked. (All variables in logs and HP-filtered.) We use quarterly data from 1987 through 2012. Table 1 reports the cyclical elasticity of the wedge and its components: labor productivity, hours worked, consumption, and taxes. The wedge is strongly countercyclical (elasticity with respect to GDP: -2.69), reflecting mildly *countercyclical* productivity (-0.10), procyclical consumption (0.61) and very procyclical hours (1.40). In recessions, the RAW increases as the mrs plummets but the mpn changes little. Using equation (1) and the results in Table 1, it is straightforward to recalculate the wedge's cyclicality for alternative calibrations of σ and η.

Table 1: **Representative Agent Wedge**

	Elasticity wrt	
	GDP	Total Hours
Representative Agent Wedge	-2.69 (0.20)	-2.00 (0.06)
Labor Productivity	-0.10 (0.08)	-0.28 (0.04)
Hours per capita	1.40 (0.07)	0.99 (0.01)
Consumption per capita	0.61 (0.03)	0.36 (0.02)
Tax Rates	0.02 (0.07)	-0.01 (0.04)

Note: Each entry is from a separate regression. Sample covers 1987Q1-2012Q4. All variables in logs and HP filtered. The wedge calculation follows equation (1) with $\sigma = 0.5$ and $\eta = 1.0$.

As shown, the contribution of marginal tax rates to the cyclicality of the RAW is small. Because our tax measures have little impact on our results, we drop them in the remainder of the paper.[3]

The Table 1 calculations ignore cyclical fluctuations in the quality of the workforce and a role for overhead labor.[4] We calculate that declines in average workforce quality in expansions lead us to understate the cyclical elasticity of labor's marginal product by 0.1 to 0.2 percent, and in turn overstate the cyclicality in the wedge. Ignoring overhead labor, conversely, overstates the procyclicality of labor's marginal product (Rotemberg and Woodford, 1999). For an overhead labor component of the magnitude suggested by Nekarda and Ramey (2013) — 10 to 20 percent of employment — the effects of composition and overhead labor on the cyclicality of labor's marginal versus average product (and on the estimated intratemporal wedge) should approximately offset.

2.1. Extensive- and Intensive-Margin Wedges

We next construct separate wedges on the extensive margin (EMW) and the intensive margin (IMW). These distinguish between the two components of hours worked, employment and hours per worker. We make this distinction for four reasons. First, we can calibrate the Frisch elasticity of labor supply to micro estimates at the hours margin. Second, we can compare the intensive margin here to the intensive margin for the self-employed (in Section 3). Third,

[3]Mulligan (2012) contends that changes in effective marginal tax rates influenced labor market behavior in the Great Recession. His focus is on how lower income workers have been affected by the expansion of means-tested assistance programs.

[4]We also ignore home production, which Karabarbounis (2014b) suggests can explain part of the cyclicality in the intratemporal wedge. Essentially, countercyclical hours worked at home imply smaller cyclical movements in effective leisure, while countercyclical consumption of home-produced goods implies smaller movements in effective consumption. Note, however, that our intertemporal and Frisch elasticities are calibrated to a literature that largely estimates models without home production. Capturing the same empirical moments with a model with home production would therefore imply lower intertemporal and Frisch elasticities. These lower elasticities would (at least) partly offset the impact of the smaller movements in effective leisure and consumption on the intratemporal wedge.

product market distortions should impact the wedge on both margins. If the intratemporal wedge is only important at one margin, it would suggest the product market wedge has little cyclical importance. Finally, although the EMW appears in many theoretical models, to our knowledge it has not been constructed empirically.

In order to analyze the extensive margin, we make some additional assumptions. We consider a representative household that consists of many members. Consumption is perfectly shared across members, and labor supply decisions are made on both the extensive and intensive margins. Preferences are given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_t^{1-1/\sigma}}{1-1/\sigma} - \nu \left(\frac{h_t^{1+1/\eta}}{1+1/\eta} + \psi \right) e_t \right\},$$

where c_t denotes per-capita consumption, e_t employment, and h_t hours worked per employee. ψ is a fixed cost of employment, which guarantees an interior solution for the choice of hours versus employment. The marginal disutility of employment is $\nu \left(\frac{h_t^{1+1/\eta}}{1+1/\eta} + \psi \right) \equiv \nu \Omega_t h_t$, while the marginal disutility of an extra hour per worker is $\nu h_t^{1/\eta} e_t$.

For firms, we assume (i) a constant output elasticity with respect to labor, and (ii) employment and hours per worker are perfect substitutes (i.e., production depends on total hours, $n_t = e_t h_t$). The marginal product of labor is thus proportional to output per hour $\frac{y_t}{n_t}$, while the marginal product of employment is $mpn_t^{ext} \propto \frac{y_t}{n_t} h_t$ and the marginal product of hours per worker is $mpn_t^{int} \propto \frac{y_t}{n_t} e_t$.

There are frictions in finding employment. Firms post vacancies at the beginning of the period, and matches form and produce during the period. [5] The matching technology is $m_t = v_t^{\phi} f(u_t)$, where m_t are matches, v_t vacancies, and u_t unemployment. κ denotes the opportunity cost of creating a vacancy, expressed in labor input as the fraction of the steady-state workweek h. δ is the

[5] Blanchard and Galí (2010) and Galí (2011) use this timing, although it is more conventional for matches to start producing in the following period. The former timing gives cleaner results, but it could be altered without changing our analysis substantially.

exogenous per-period separation rate. γ is the fraction of the initial period of employment devoted to training.

In this environment, the intensive margin wedge is given by

$$IMW_t \equiv \ln(mpn_t^{int}) - \ln(mrs_t^{int}) = \ln\left(\frac{y_t}{n_t}\right) - \left[\frac{1}{\sigma}\ln(c_t) + \frac{1}{\eta}\ln(h_t)\right]. \qquad (2)$$

The IMW in (2) differs from the standard RAW in (1), in two ways: hours per worker h_t replaces hours per capita n_t, and we calibrate $\eta = 0.5$. A lower η is appropriate given it now reflects the Frisch elasticity only at the intensive (hours) margin (Chetty et al., 2013).[6]

On the extensive margin, consider creating one more vacancy in period t and reducing vacancies in $t+1$ just enough to keep employment unaffected in $t+1$ forward. Spending $\kappa h \frac{y_t}{n_t}$ to create an additional vacancy generates $\phi m_t / v_t$ additional matches, of which $(1-\delta)$ survive to $t+1$. The perturbation thus requires lower spending on vacancies at $t+1$ by $(1-\delta)\kappa h \frac{y_{t+1}}{n_{t+1}} \frac{m_t/v_t}{m_{t+1}/v_{t+1}}$. A social planner would set:

$$\begin{aligned} &\frac{\phi m_t}{v_t}\left[u'(c_t)\left(1-\gamma\frac{h}{h_t}\right)h_t\frac{y_t}{n_t} - \Omega_t h_t\right] - u'(c_t)\kappa h\frac{y_t}{n_t} \\ &+\beta(1-\delta)\mathbb{E}_t\left\{u'(c_{t+1})\left(\kappa h\frac{y_{t+1}}{n_{t+1}}\frac{m_t/v_t}{m_{t+1}/v_{t+1}} + \frac{\phi m_t}{v_t}\gamma h\frac{y_{t+1}}{n_{t+1}}\right)\right\} = 0. \end{aligned} \qquad (3)$$

The marginal benefit of an extra vacancy (utility from consuming increased output today) equals its marginal cost (disutility of employment plus the cost of creating an added vacancy today less the resource savings from creating fewer future vacancies). Rearranging (3) to get a (log) ratio of the marginal benefit to the marginal cost of additional labor on the extensive margin:

$$EMW_t = \ln\left(\frac{y_t}{n_t}\right) - \left[\frac{1}{\sigma}\ln(c_t) + \ln(\Omega_t)\right] - S_t,$$

[6]Pescatori and Tasci (2012) point out that the intratemporal wedge is less variable when calculated using hours per worker rather than hours per capita. They, however, hold the Frisch elasticity fixed across the workweek and representative agent calculations.

$$S_t \approx \frac{\frac{h}{h_t}\left(\frac{\kappa v}{\phi m}\frac{\frac{v_t}{v}}{\frac{m_t}{m}}\left[1-\beta(1-\delta)\mathbb{E}_t\left\{\frac{u'(c_{t+1})}{u'(c_t)}\frac{\frac{y_{t+1}}{n_{t+1}}}{\frac{y_t}{n_t}}\frac{\frac{v_{t+1}}{v_t}}{\frac{m_{t+1}}{m_t}}\right\}\right]+\gamma\left[1-\beta(1-\delta)\mathbb{E}_t\left\{\frac{u'(c_{t+1})}{u'(c_t)}\frac{\frac{y_{t+1}}{n_{t+1}}}{\frac{y_t}{n_t}}\right\}\right]\right)}{1-[1-\beta(1-\delta)]\left[\frac{\kappa v}{\phi m}+\gamma\right]}, \tag{4}$$

where Ω_t is the marginal disutility of employment (per hour worked).[7]

The EMW, like the IMW, reflects movements in labor productivity, $\ln\left(\frac{y_t}{n_t}\right)$, and the marginal utility of consumption, $\frac{1}{\sigma}\ln(c_t)$. But there are differences from the IMW. Whereas the IMW reflects the marginal disutility of an extra hour, which is highly proyclical for reasonable Frisch elasticities, the extensive margin reflects the average disutility of adding a worker. We find this average disutility to be nearly acyclical. In addition, the term S_t, which is specific to the EMW, reflects the efficacy of spending on vacancies. In recessions S_t declines as vacancies are more likely to yield a match. This lends a countercyclical component to the EMW. The cyclicality of the EMW vis-a-vis the IMW essentially reduces to whether cyclicality in the hiring term S_t exceeds that in the marginal disutility of working a longer workweek.

It is well established that cyclical movements in total hours are primarily driven by employment fluctuations. That holds true for our 1987 to 2012 period, where cyclical employment fluctuations (with respect to real GDP or total hours) are about four times larger than in the workweek. One might jump to the conclusion that cyclicality in the extensive (employment) margin *wedge* would similarly dominate cyclicality in the intensive (workweek) margin *wedge*. That jump would be unwarranted. Important components of the wedge — i.e., labor's marginal product and consumption's marginal utility — display the same cyclicality with respect to both margins. Any wedge differences, as just discussed, reduce to cyclicality in the hiring term S_t versus that in the marginal disutility of working a longer workweek. While employment fluctuations are larger than those in the workweek, the elasticity of the marginal disutility in response to the workweek may exceed that of the

[7]The approximation stems from our use of a first order Taylor series approximation at several points. The Appendix provides more details on the EMW (and IMW) construction.

hiring cost S_t to employment.

To construct the EMW, we use the same variables required by the IMW, plus vacancies (v_t), matches (m_t), and additional parameters. A quarterly separation rate of $\delta = 0.105$ matches the average rate of quits, layoffs, and discharges in JOLTS. $\beta = 0.996$ implies a steady-state annual real interest rate of 1.6%, the average of the 3–month T–bill rate less core PCE inflation over our sample. Hiring costs per match, $\frac{\kappa v}{m}$, are set to 0.4 quarters of output, and training costs to $\gamma = 0.16$, consistent with estimates by Barron et al. (1999). Finally, the elasticity of matches to vacancies is set to $\phi = 0.5$. These parameter values imply a steady-state ratio of mrs to mpn on the extensive margin of about 0.90.

Figure 1 shows the unfiltered extensive and intensive margin wedges from 1987–2012. Table 2 reports their cyclical elasticities with respect to real GDP and hours worked. The EMW and IMW elasticities are quite similar. The EMW and IMW elasticities are smaller than for the RAW; an aggregate Frisch elasticity of 2.3 would make the RAW behave similarly to the EMW and IMW.

Figure 1: EMW vs. IMW (Unfiltered)

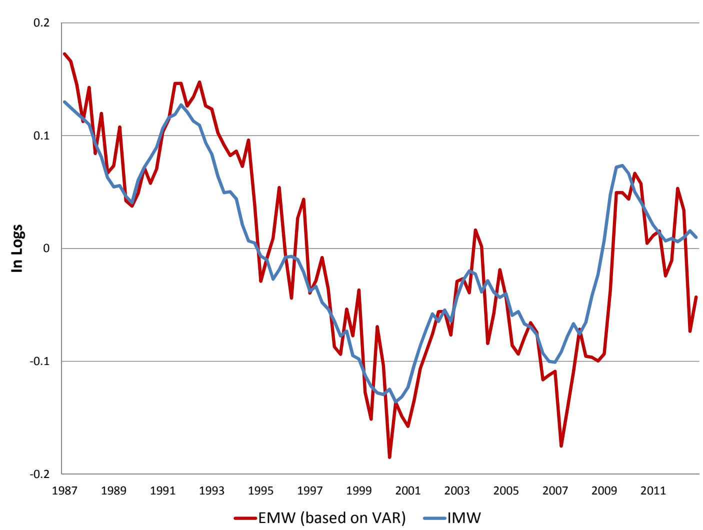


Table 2: **Extensive & Intensive Margin Wedges**

	Elasticity wrt	
	GDP	Total Hours
Extensive Margin Wedge	-1.99 (0.26)	-1.55 (0.14)
Intensive Margin Wedge	-1.91 (0.13)	-1.38 (0.05)

Note: Each entry is from a separate regression. Sample covers 1987Q1-2012Q4. All variables in logs and HP-filtered. Wedge calculations, equations (2) and (4), use $\sigma = 0.5$ and $\eta = 0.5$, and EMW expectation terms are constructed by a VAR.

2.2. Decomposing the Wedge

We now empirically decompose the intratemporal wedge into product-market (i.e., price markup) and labor-market (i.e., wage markup) components. This requires a measure of the marginal cost of labor to firms. As stressed by Galí, Gertler, and Lopez-Salido (2007), the assumption that any particular wage measure reflects labor's true marginal cost is controversial. We will show that alternative wage measures lead to vastly different conclusions about the relative importance of the product- and labor-market wedges. This motivates our subsequent analysis, which decomposes the intratemporal wedge without using wage data.

The IMW decomposition is standard and given by

$$\begin{aligned} IMW_t &= \left[\ln\left(\frac{y_t}{n_t}\right) - \ln\left(\frac{w_t}{p_t}\right)\right] + \left[\ln\left(\frac{w_t}{p_t}\right) - \frac{1}{\sigma}\ln(c_t) - \frac{1}{\eta}\ln(h_t)\right] \\ &= \mu_t^{p,int} + \mu_t^{w,int}, \end{aligned} \tag{5}$$

where $\frac{w_t}{p_t}$ is the (real) marginal cost of labor to firms. The intensive product market wedge ($\mu^{p,int}$) is the gap between the firm's marginal product and marginal cost of labor. The intensive labor market wedge ($\mu^{w,int}$) is the gap between the firm's marginal cost and the household's cost of providing an additional hour.

The EMW decomposition is

$$\begin{aligned} EMW_t &= \left[\ln\left(\frac{y_t}{n_t}\right) - \tilde{S}_t - \ln\left(\frac{w_t}{p_t}\right)\right] + \left[\ln\left(\frac{w_t}{p_t}\right) + \tilde{S}_t - S_t - \frac{1}{\sigma}\ln(c_t) - \ln(\Omega_t)\right] \\ &= \mu_t^{p,ext} + \mu_t^{w,ext}, \end{aligned} \tag{6}$$

where $\tilde{S}_t$ takes the same form as S_t in equation (4) but with $\phi = 1$. For intuition, temporarily let $\tilde{S}_t = S_t$ in equation (6). Doing so, it is apparent that the extensive labor-market wedge ($\mu^{w,ext}$) mirrors the intensive ($\mu^{w,int}$), but with the household's mrs along the employment margin. For the extensive product-market wedge ($\mu^{p,ext}$), an additional employee produces $\ln\left(\frac{y_t}{n_t}\right) - S_t$ because firms pay the vacancy cost (S_t). Finally, using $\tilde{S}_t$ rather than S_t reflects the fact that firms do not internalize the congestion effects of their decision to post another vacancy; each firm views the probability of filling a vacancy as $\frac{m}{v}$, whereas the social planner knows one more vacancy generates $\frac{\phi m}{v}$ additional matches.

Table 3 decomposes the EMW and IMW into product- and labor-market wedges using average hourly earnings (AHE) as the measure of the firm's marginal cost of labor (w_t). This wage measure is conventional and would reflect the true marginal cost if all workers were employed in spot markets. In this case, $\ln\left(\frac{y_t}{n_t}\right) - \ln\left(\frac{w_t}{p_t}\right)$ is the (log) inverse labor share. Using AHE, the product-market wedge accounts for only 2 to 6% of the cyclicality of the intratemporal wedge on the intensive margin, and between 16 and 23% on the extensive margin. These results are in line with Karabarbounis' (2014a) conclusion that the product market wedge is relatively unimportant.

Alternative frameworks for understanding the labor market, however, emphasize the durable nature of the firm-worker relationship and imply the contemporaneous wage plays no allocative role. For example, in matching

Table 3: **Wedge Decomposition: Average Wage**

	Elasticity wrt	
	GDP	Total Hours
Extensive Margin Wedge	-1.99 (0.26)	-1.55 (0.14)
Product Market (AHE)	-0.32 (0.14)	-0.35 (0.09)
Intensive Margin Wedge	-1.91 (0.13)	-1.38 (0.05)
Product Market (AHE)	-0.04 (0.08)	-0.08 (0.05)

Note: Each entry is from a separate regression. Sample is from 1987Q1 through 2012Q4. All variables in logs and HP filtered. Expectation terms in EMW constructed using a VAR. The extensive product market wedge ($\mu^{p,ext}$) follows equation (6), and the intensive product market wedge ($\mu^{p,int}$) follows equation (5).

models with search frictions, what matters is the expected surplus generated over the life of the match and not the wage payment at any one time. Implicit contracting models similarly imply that the flow wage payment is not allocative. Barro (1977) and Rosen (1985) forcefully drive home that an acyclical wage, or even countercyclical wage, can coincide with a highly procyclical true price of labor. (See Basu and House, 2015, as well.) Recent examples of empirical support for implicit contracting include Ham and Reilly (2013) and Bellou and Kaymak (2012).[8]

In light of this, Table 4 shows how alternative measures of firms' marginal cost of labor affect the wedge decomposition. We consider the wages of new hires (NH) and Kudlyak's (2014) user cost of labor (UC), which have been argued to be more relevant for job formation in search frameworks.[9] We therefore also

[8]Ham and Reilly (2013) compare spot market, implicit contract, and disequilibrium models of hours determination, finding only the implicit contract model consistent with the data. Bellou and Kaymak (2012) find that workers hired during recessions receive larger wage raises during expansions, and are subject to smaller wage cuts during downswings, while changes in contemporaneous conditions are not significant for wage growth. They show these findings are consistent with implicit insurance contracts without commitment.

[9]See Pissarides (2009), Haefke, Sonntage, and van Rens (2013), and Kudlyak (2014). Kudlyak

focus on the extensive margin. We find that, depending on the wage measure used, the product market wedge can account for almost none or essentially all of the EMW — from 16% using average hourly earnings to 109% using user cost. (Using the user cost of labor, the product market wedge also accounts for all cyclicality in the intensive margin wedge from Table 3.)

Table 4: **Wedge Decomposition: Alternative Wage Measures**

	Elasticity wrt	
	GDP	Total Hours
Extensive Margin Wedge	-1.99 (0.26)	-1.55 (0.14)
Product Market (AHE)	-0.32 (0.14)	-0.35 (0.09)
Product Market (NH)	-0.98 (0.16)	-0.81 (0.09)
Product Market (UC)	-2.17 (0.21)	-1.65 (0.09)

Note: Each entry is from a separate regression. Sample is from 1987Q1 through 2012Q4. All variables in logs and HP filtered. Expectation terms in the EMW are constructed using a VAR. The product market wedge follows equation (6).

3. The Self-Employed Wedge

Given the ambiguity of results presented in the previous section, it is useful to explore decompositions of the intratemporal wedge that do not depend on wage data. We now consider the intratemporal wedge specifically for the self-employed. The decomposition is

finds that the new hire wage falls 1.2% relative to all workers' wages for each percentage point rise in the unemployment rate, while the relative fall in the user cost of labor is 3.4%. The results in Table 4 reflect adjusting the time series of average hourly earnings by these cyclical factors, as explained in the Appendix.

$$\mu_{SE} = \underbrace{\ln (mpn)_{SE} - \ln \left(\frac{w}{p}\right)_{SE}}_{\mu^p{}_{SE}} + \underbrace{\ln \left(\frac{w}{p}\right)_{SE} - \ln (mrs)_{SE}}_{\mu^w{}_{SE}}.$$

We assume $\mu^w_{SE} = 0$. That is, we assume the marginal price of a self-employed person's own labor $\left(\frac{w}{p}\right)_{SE}$ is equal to their *mrs* because no wage rigidities or other labor market distortions impinge on their decision to supply labor to their own business. This implies that any intratemporal wedge for the self-employed must be due to the product market wedge:

$$\mu_{SE} = \underbrace{\ln (mpn)_{SE} - \ln (mrs)_{SE}}_{\mu^p{}_{SE}}.$$

Note that, by assuming $\mu^w_{SE} = 0$, we can use mrs_{SE} as our measure of the unobserved shadow wage for the self-employed $\left(\frac{w}{p}\right)_{SE}$.

To see if the intratemporal wedge — and hence the product market wedge — is cyclical for the self-employed, we turn to the Current Population Survey (CPS) and Consumer Expenditure Survey (CE). We first document the cyclical behavior of self-employed hours worked and then check whether movements in productivity and consumption can explain these fluctuations.

As a starting point, we note that self-employment has been as cyclical as total employment.[10] The *share* of self-employed in nonagricultural industries declined slightly during each of the past two NBER-defined recessions: from 10.1 to 10.0 percent during 2001 and from 10.5 to 10.4 percent from 2007 to 2009. The self-employment share exhibits lower-frequency fluctuations, but if we HP-filter the resulting series is completely acyclical with respect to GDP or aggregate hours.[11] Becoming self-employed requires starting a business, so

[10]Hipple (2010) reports annual rates of self-employment in the U.S. for 1994 to 2009 based on the monthly CPS, and these series are extended through 2012 (based on Hipple input) by Heim (2014). The Hipple series reflect both incorporated and unincorporated self-employed. Incorporated self-employed constitute about one third of total self-employed.

[11]These numbers are for nonagriculture, which represents 94 percent of the self-employed. For agriculture, self-employment (again from Hipple) is acyclical. We focus on nonagriculture workers as top and bottom coding of income in the CPS is extreme for farmers. For farmers

fluctuations in self-employment could be affected by financing costs and constraints. In particular, the decline in self-employment during the Great Recession may partly reflect financing constraints. Going forward, we thus focus on the intensive (hours) margin for the self-employed.

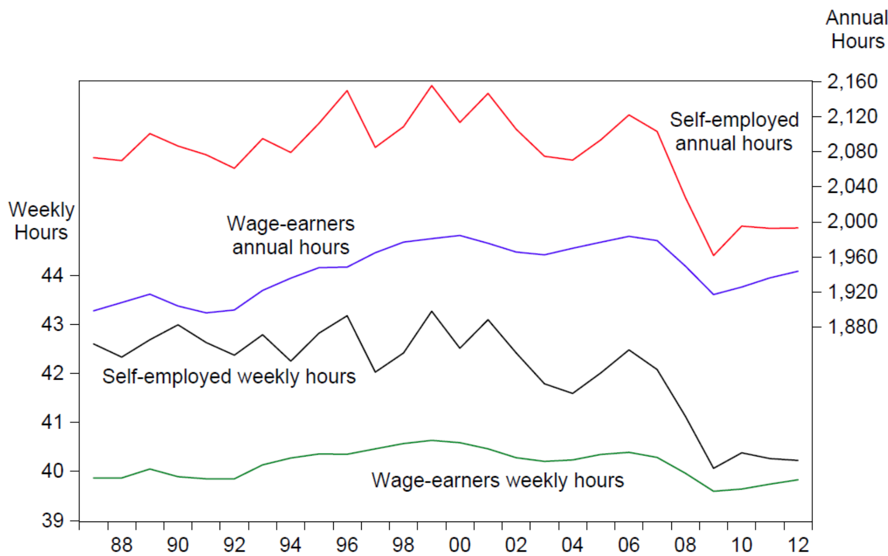
We base our analysis on the Annual Social and Economic supplements to the CPS, typically referred to as the March CPS. In the March supplement household members report their hours and income for the previous calendar year. They also report the income and class of worker at their primary job — the job held longest during the prior year. The class-of-worker variables allow us to distinguish the self-employed separately for agriculture and non-agriculture. We begin our sample in 1987, the first year that data on primary-job income is available. Advantages of the March supplement are: (i) it is large; (ii) its top-coding of income is less extreme than in the monthly surveys; and (iii) some households can be matched across two consecutive March surveys, allowing us to examine year-over-year changes for a given set of workers. Our unmatched sample contains 197,723 self-employed individuals for 1987 to 2012 (1,901,936 wage earners).[12]

Figure 2 reports usual weekly hours and total annual hours worked separately for the self-employed (nonagricultural) and for those earning wages and salaries for 1987 to 2012. The intensive margin is clearly more cyclical for the self-employed. If we regress hours per week on real GDP (both series in logs and HP-filtered), the elasticity for the self-employed (0.37, standard error 0.14) is nearly twice that for wage earners (0.20, s.e. 0.02). During the Great Recession (2007-2009), the workweek for the self-employed declined by 4.9

it is also implausible to treat realized income as known at the time labor input is chosen, an assumption implicit in calculations of the intratemporal wedge.

[12]We require that workers be between ages 20 and 70 and work at least 10 hours per week and at least 10 weeks during the year. Some income and hours responses are top coded. For each survey we trim the top and bottom 9.6% of observations by income on primary job. 9.6% is just large enough to remove top-coding of business income for the self-employed in all 26 years. We trim the bottom for symmetry; this also serves to remove all negative income entries. Usual hours are top coded at 99 per week. We trim the top 1.2 percent of workers by weekly hours. This is the minimal trimming that removes top-coded hours for all years.

Figure 2: Hours for the Self-employed vs. Wage-earners



percent (2 full hours) compared to only 1.7 percent for wage earners. Similarly, annual hours declined by 6.9 percent for the self-employed, compared to 3.2 percent for wage earners.

Figure 2 might be influenced by composition bias. For example, if workers becoming self-employed in expansions work more hours than the typical self-employed, then hours in Figure 2 will have a procyclical bias. For this reason, we match self-employed individuals across consecutive March supplements, constructing growth rates for their hours and income.[13] Using these growth rates, we express hours and income relative to 1987. We are not able to match across 1994 and 1995 calendar years due to a CPS sample redesign. For 1994-1995 we impute to each series its mean growth rate. We then create a level series indexed to 1987. In all subsequent statistics, we exclude years 1994 and 1995. Our matched sample includes 39,306

[13]We follow standard matching procedures for the March CPS. Respondents are matched across years based on household and person identifiers and conformity of each respondent's sex, race, and age.

self-employed individuals, prior to trimming to deal with top coding.[14]

Comparing these hours indices for the self-employed and wage-earners, the workweek is more cyclical for the self-employed. The elasticity of the workweek with respect to real GDP (both variables HP-filtered) is 0.28 (s.e. 0.07) for the self-employed versus 0.17 (s.e. 0.03) for wage-earners. Annual hours are slightly more cyclical for wage-earners, with an elasticity with respect to real GDP of 0.57 (s.e. 0.07), compared to 0.54 (s.e. 0.13) for the self-employed. Similar remarks apply if we measure the cycle by aggregate hours.

In Table 5 we report the cyclicality of the intensive-margin intratemporal wedge. The first column is estimated for all workers, not just the self-employed. It repeats the analysis from Section 2 equation (2), but uses workweek fluctuations constructed from the matched-CPS surveys. It is also annual, rather than quarterly, and excludes years 1994 and 1995 because we are unable to match those years in the CPS. It dispenses with the tax wedge, which we found to have little impact. As in Section 2, we find a strongly countercyclical wedge. The elasticities of the wedge with respect to real GDP and aggregate hours, -1.87 and -1.20, are modestly smaller than reported in Table 2 (estimates there being -1.91 and -1.38), with the difference reflecting a slightly less procyclical workweek.

Columns 2-4 of Table 5 show how the wedge's cyclicality changes as we sequentially replace the estimates of cyclicality in hours, productivity, and consumption for all workers with estimates for the self-employed.[15] Column 2 constructs the wedge using fluctuations in the workweek just for the self-employed, maintaining the same aggregate series for productivity and consumption. Not surprising, given the greater cyclicality of the workweek for

[14]The March CPS responses for weeks worked and usual hours per week are for all prior-year jobs, whereas class of worker and income refer to the primary (longest-held) job. To achieve an income-compatible measure of hours growth, we restrict our self-employed sample to those who received 95 percent of income from their primary self-employed job. (The average of that income share across the two years must be at least 0.95.)

[15]Figures A1-A4 in the Appendix plot the series that underlie these estimates.

Table 5: **Cyclicality of Intratemporal Wedge, All Workers vs. Self-Employed**

Elasticity wrt	(1)	(2)	(3)	(4)
Real GDP	-1.87 (0.10)	-2.06 (0.17)	-1.97 (0.25)	-3.23 (1.00)
Total Hours	-1.20 (0.05)	-1.41 (0.10)	-1.29 (0.16)	-1.93 (0.61)
Hours	All workers	SE	SE	SE
MPN	Agg. y/n	Agg. y/n	SE inc/hr	SE inc/hr
Consumption	NIPA PCE	NIPA PCE	NIPA PCE	+ CE Adj.

Notes: The intratemporal wedge is constructed according to equation (2). Sample is based on matched-March CPS self-employed outside government and agriculture. CPS observations are weighted. Each cell represents a separate regression. Regressions have 24 annual observations, 1987-1993 and 1996-2012. Newey-West standard errors are in parentheses. Hours are weekly. NIPA PCE refers to aggregate real expenditures on nondurables and services. CE adjustment incorporates consumption for the self-employed vs. all persons from the Consumer Expenditure Surveys.

the self-employed described previously, this results in a slightly more cyclical intratemporal wedge. The elasticity with respect to real GDP goes from -1.87 (s.e. 0.10) to -2.06 (s.e. 0.17).[16]

We next replace aggregate labor productivity with a measure of productivity specific to the self-employed. Our measure is self-employed annual business income divided by their annual hours worked in their business.[17]

[16]If we used fluctuations in annual hours, rather than weekly hours, then the wedge in column 1 with respect to real GDP, maintaining a Frisch elasticity of 0.5, would become -2.66 (s.e. 0.15), while that in column 2 would become -2.60 (s.e. 0.24).

[17]We deflate business income by the nondurables and services PCE deflator. We use the midpoint formula to calculate the percentage change in self-employed income across matched

Self-employed business income per hour is proportional to the marginal product of self-employed labor assuming: (i) a constant elasticity of output with respect to self-employed labor, as with Cobb-Douglas production in Section 2; and (ii) self-employed income is proportional to business output. This second assumption is likely to be violated: self-employed income probably includes some returns to equity in the business, not just self-employed labor. This should lead us to overstate the procyclicality of the marginal product of labor for the self-employed, because their residual equity claim on business revenue is likely to be more procyclical than business output. This means we probably *understate* the countercyclicality of the self-employed intratemporal wedge.

An additional factor that works to understate countercyclicality of the intratemporal wedge is that our self-employed productivity measure ignores any overhead component of self-employed labor. This could be especially important given the small scale of operations for much self-employed production. A final concern is that reported income could misstate actual income. The self-employed tend to understate income. Hurst, Li, and Pugsley (2014) show that the ratio of consumption to income is higher in survey data for the self-employed, consistent with the self-employed understating income. The concern for us would be if the self-employed underreport at a lower rate in recessions.

Going from Column 2 to 3 of Table 5, we replace aggregate labor productivity with self-employed business income per hour. Aggregate labor productivity has been modestly countercyclical since 1987, with an elasticity with respect to real GDP of -0.21 (s.e. 0.07). Self-employed business income per hour has been less cyclical (elasticity -0.13, s.e. 0.19). Thus, the estimated intratemporal wedge becomes slightly less countercyclical, with an elasticity of -1.97 (s.e. 0.25) with respect to real GDP. In summary, the wedge calculated

years. This avoids extreme values for individuals with very low income in one of the matched years.

Figure 3: Intratemporal Wedge for the Self-Employed vs. All Workers

with measured productivity *and* hours for the self-employed is just as cyclical as that for all workers. Figure 3 plots the time series of these two wedges.

We have assumed the cyclicality of consumption for the self-employed is the same as for consumption per capita. For robustness, we estimate self-employed consumption relative to aggregate consumption based on quarterly growth rates in household spending on nondurables and services in the Consumer Expenditure Surveys (CE). We add these estimates of relative consumption to aggregate consumption to obtain an estimate of consumption for the self-employed.

The elasticity of aggregate consumption with respect to real GDP is 0.64 (s.e. 0.04). Self-employed consumption is even more procyclical, with an elasticity of 1.27. But the standard error is too large, at 0.56, to reliably infer that the self-employed have more procyclical consumption. The big standard error reflects the small number of self-employed observations in the CE. If we do use this measure of consumption, however, we get an even more cyclical wedge for the self-employed. This is illustrated in the last column of Table 5.

The self-employed intratemporal wedge now exhibits an elasticity of -3.23 (s.e. 1.00) with respect to real GDP. In this section's subsequent exercises, we revert to measuring self-employed consumption by aggregate consumption, rather than adopting such a noisy measure.[18]

Table 6 presents two robustness exercises. First, self-employed who are incorporated might take income in the form of corporate profits rather than business income. It is not obvious how the incorporated self-employed treat these profits in answering the CPS question about their business income. For this reason, as an alternative measure of labor productivity, we consider business income per hour excluding the incorporated self-employed. This series is more procyclical than business income per hour for all self-employed. Its elasticity with respect to real GDP is 0.28 (s.e. 0.26), whereas the measure for all self-employed is slightly countercyclical. The first two columns of Table 6 repeat Columns 1 and 3 from Table 5, while Table 6, Column 3 measures productivity by business income per hour for those not incorporated. The wedge becomes less countercyclical, with an elasticity with respect to real GDP of -1.57 (s.e. 0.24). Nevertheless, the self-employed intratemporal wedge remains extremely cyclical, and still nearly as cyclical as that for all workers (Column 1).[19]

A second robustness exercise considers that the self-employed are distributed differently across industries than are wage earners. For instance, self-employment is about twice as frequent in construction, a highly cyclical industry, than overall. Self-employment is considerably less common in durable manufacturing, which is also highly cyclical. We constructed a

[18]We also examined cyclicality of consumer expenditure for the self-employed in the Panel Study of Income Dynamics (PSID). The PSID has reasonably broad expenditure measures starting in 1999, but only biannually. In the PSID self-employed consumption *relative* to consumption of all households dropped by 2.8% from 2007 to 2009, corresponding to the most recent recession. (Unfortunately, biannual observations miss the timing of the 8-month recession during 2001.) But, overall, the PSID numbers suggest similar cyclicality of consumption for the self-employed as for all households.

[19]A wedge constructed solely for those not incorporated is slightly less cyclical than in Column 3 (elasticity of -1.39 with respect to real GDP).

Table 6: **Intratemporal Wedge, All vs. Self-Employed, Alternatives**

Elasticity wrt	(1)	(2)	(3)	(4)
Real GDP	-1.87 (0.10)	-1.97 (0.25)	-1.57 (0.24)	-1.64 (0.32)
Total Hours	-1.20 (0.05)	-1.29 (0.16)	-1.03 (0.20)	-1.03 (0.19)
Hours	All workers	SE	SE	SE
MPN	Agg. y/n	SE inc/hr	Uninc SE inc/hr	SE inc/hr
CPS weighting	CPS weights	CPS weights	CPS weights	+ Ind. shares

Notes: Intratemporal wedge constructed according to equation (2). Sample is based on matched-March CPS self-employed outside government and agriculture. CPS observations are weighted. Each cell represents a separate regression. Regressions have 24 annual observations, 1987-1993 and 1996-2012. Newey-West standard errors are in parentheses. Hours are weekly. NIPA PCE consumption.

self-employed intratemporal wedge reweighting observations by industry so that the weighted shares of the self-employed by industry mimics that for all workers. We do this for a breakdown of 12 major industries. For example, if self-employment is twice as frequent in construction, then the self-employed in construction are down-weighted by a factor of one-half. The results are given in Table 6, Column 4. The cyclicality of the self-employed wedge is modestly reduced. The elasticity is now -1.64 (s.e. 0.32) with respect to real GDP. Again, however, it remains extremely cyclical, nearly as cyclical as for all workers.[20]

[20] As discussed in Section 2, if the calibration is misspecified by ignoring countercyclical home production, this can impart some cyclicality to the intratemporal wedge (Karabarbounis,

We conclude that the self-employed exhibit a highly countercyclical intratemporal wedge. Depending on specification choices, it is either as cyclical as the wedge calculated for all workers or nearly as cyclical. Because this wedge is presumably not driven by wage or other labor market distortions, it is evidence of a highly countercyclical product market wedge. By extension, we find it suggestive of a countercyclical product market wedge for the overall economy.

4. Intermediate Inputs

The conventional way to estimate the product market wedge (μ^p) is based on the inverse labor share of income, e.g., Karabarbounis (2014a). But, in principle, any input with a well-measured marginal product and marginal price can be used to infer marginal cost and thus price markups. Here we investigate the cyclicality of spending on intermediate inputs — materials, energy, and services — relative to gross output.

Intermediate inputs are promising for several reasons. First, intermediates are used by all industries. Second, adjustment costs for intermediates are believed to be low relative to adjustment costs for capital or even labor. See Basu (1995) or Levinsohn and Petrin (2003). Third, the assumption of no overhead component seems more defensible for intermediates than for labor.

One question is whether intermediate prices reflect the marginal cost of intermediate inputs. Long term relationships between firms and suppliers could raise the same implicit contracting issues that arise with labor. Still, intermediates offer an independent piece of evidence vis-a-vis labor. And, as with labor, one would expect price smoothing relative to true input costs to impart a procyclical bias to the estimated μ^p.

2014b). Could this misspecification fall disproportionately on the self-employed? This would require that the self-employed have a *comparative* advantage in home production. As the self-employed exhibit higher average market earnings, they would need to be even more able at home production.

4.1. Technology for Gross Output

We assume a CES production function for gross output in an industry:

$$y = \left[\theta m^{1-\frac{1}{\varepsilon}} + (1-\theta)\left[z_v\left[(1-\alpha)k^{1-\frac{1}{\omega}} + \alpha(z_n n)^{1-\frac{1}{\omega}}\right]^{\frac{\omega}{\omega-1}}\right]^{1-\frac{1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}$$

where y denotes gross output, m intermediate inputs, k capital, and n labor. Technology shocks can be specific to value added (z_v) or labor (z_n). The elasticity of substitution between intermediates and value added is ε, the elasticity of substitution between capital and labor within value added is ω.

With this technology the marginal product of output with respect to intermediate inputs is

$$\frac{\partial y}{\partial m} = \theta\left(\frac{y}{m}\right)^{\frac{1}{\varepsilon}}.$$

Based on this marginal product, we can estimate the product market wedge as

$$\mu^p = \frac{p}{p_m / \frac{\partial y}{\partial m}} = \frac{p\,\theta\left(\frac{y}{m}\right)^{\frac{1}{\varepsilon}}}{p_m}. \tag{7}$$

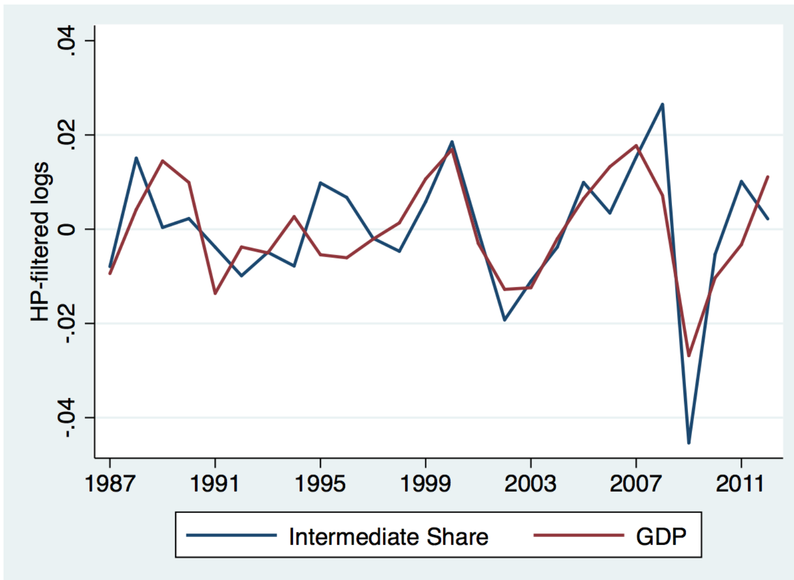
In the special case of Cobb-Douglas aggregation of intermediates and value added ($\varepsilon = 1$), the product market wedge is the inverse of intermediates' share:

$$\mu^p = \frac{\theta\, p\, y}{p_m\, m}$$

A higher price-cost markup boosts gross output relative to spending on intermediates. This is analogous to using inverse labor's share to measure price markup movements. A countercyclical markup would show up as a procyclical intermediate inputs share.[21]

[21] Although there is unlikely to be an overhead component to intermediates, one may still be concerned about fixed costs of production. Suppose $y_t = f_t - \Gamma$, where f_t is our CES production function and Γ is a fixed cost. In the Cobb-Douglas case, this would imply $\mu_t^p = \theta\frac{p_t y_t}{p_{mt} m_t}\left(1+\frac{\Gamma}{y_t}\right)$. Thus, if fixed costs are important, our estimates will *understate* the countercyclicality of the product market wedge.

Figure 4: Cyclicality of Intermediate Share



4.2. Evidence on the Cyclicality of Intermediate Inputs

We use the Multifactor Productivity Database from the U.S. Bureau of Labor Statistics on industry gross output and KLEMS inputs (capital, labor, energy, materials and services). It contains annual data from 1987–2012 and covers 60 industries (18 in manufacturing).[22]

In the Cobb-Douglas case of $\varepsilon = 1$, a procyclical intermediate share implies a countercyclical markup. Figure 4 plots the weighted-average industry intermediate share against GDP, where both variables are in logs and HP-filtered. As shown, spending on intermediates relative to gross output is highly procyclical.

To explore this more systematically, we next run regressions of the intermediate-based product market wedge on the cycle. Based on equation (7), the specification is

[22]The Appendix provides more details. KLEMS intermediate inputs come from BEA annual input-output accounts. These reflect purchases during the year minus inventory accumulation. See www.bea.gov/papers/pdf/IOmanual_092906.pdf.

$$\log\left(\frac{p_{it}}{p_{mit}}\left(\frac{y_{it}}{m_{it}}\right)^{\frac{1}{\varepsilon}}\right) = \alpha_i + \beta^p\, log(cyc_t) + \epsilon_{it}$$

where cyc_t is either real GDP or hours worked, and all variables are HP filtered. The industry fixed effects (α_i) should take out changes in the aggregate share due to shifting industry composition over the cycle. We weight industries by the average share of their value added in all industry value added from 1987–2012. Standard errors are clustered by year.

Table 7 presents the results. Consider first the case of $\varepsilon = 1$, in which production is Cobb-Douglas in intermediates and value added. The product market wedge is estimated to be highly countercyclical. This is true for both measures of the cycle (based on GDP or total hours worked), for all industries together, and separately for manufacturing and non-manufacturing industries. Though not reported in the Table, it is also true if we weight industry-years by Tornqvist value added shares rather than industry shares over the entire sample, and if we use growth rates rather than HP-filtered series.

For manufacturing, we can break intermediate inputs into materials, energy, and services. As Table 7 shows, the inverse shares for materials and energy are both countercyclical, and significantly so. The inverse share of spending on services, in contrast, is procyclical. Perhaps services are contracted less in spot markets than materials or energy.[23]

It is often argued that is tough to substitute between intermediates and value added. Bruno (1984) and Rotemberg and Woodford (1996) estimate elasticities of 0.45 and 0.69, respectively, for U.S. manufacturing. Oberfield and Raval (2014) obtain estimates ranging from 0.63 to 0.90 by looking across regions in U.S. manufacturing. Atalay (2014) estimates even smaller elasticities (below 0.1). We therefore show results using $\varepsilon = 1/2$ in Table 7. As shown, a smaller elasticity makes the μ^p based on intermediates *more* countercyclical.

[23] Outside manufacturing we can only break intermediates into these components for 1997-2012. For all industries together, the inverse services share is acyclical, while the inverse shares of materials and energy are countercyclical.

Table 7: **Cyclicality of the Product Market Wedge Using Intermediates**

	$\varepsilon = 1$		$\varepsilon = 0.5$	
Elasticity wrt →	GDP	Hours	GDP	Hours
All Industries	-0.94 (0.24)	-0.59 (0.15)	-1.72 (0.45)	-1.08 (0.28)
Non-Mfg.	-0.94 (0.24)	-0.57 (0.16)	-1.85 (0.48)	-1.15 (0.31)
Manufacturing	-0.95 (0.32)	-0.65 (0.20)	-1.24 (0.53)	-0.83 (0.35)
Materials	-1.56 (0.52)	-1.03 (0.32)	-2.21 (0.86)	-1.39 (0.56)
Services	1.49 (0.68)	0.92 (0.43)	2.70 (1.26)	1.61 (0.82)
Energy	-1.97 (1.05)	-1.58 (0.69)	-3.19 (2.19)	-2.77 (1.34)

Note: Each entry is from a separate regression. Annual data from 1987-2012 for 60 industries (1560 industry-year observations), 18 manufacturing and 42 non-manufacturing. All variables in logs and HP filtered. Regressions include industry fixed effects and use industry average value added shares as weights. Standard errors are clustered by year.

Because firms are shifting toward intermediates in booms, the marginal product of intermediates will fall faster if substitutability is more limited, making marginal cost more procyclical. Thus the price-cost markups implied by intermediate inputs becomes more countercyclical.

In the KLEMS data, both the price and quantity of intermediates are procyclical relative to labor, if one uses average hourly earnings (AHE) as the price of labor. The elasticity of p_m/w with respect to real GDP is 0.65 (standard error 0.16), while the elasticity of m/n with respect to real GDP is 1.19 (standard error 0.37). Why do firms shift toward intermediates, over labor, in booms if intermediates become relatively expensive? One answer is that AHE understates cyclicality in the price of labor, perhaps because of wage smoothing, with labor's price even more procyclical than that of intermediates. That implies a much more procyclical marginal cost and, in turn, much more countercyclical markup than judged by AHE.

What share of the intratemporal wedge might be accounted for by the μ^p we obtain from intermediates? To answer this, we construct an industry-specific intratemporal wedge that is consistent with the gross-output production function we consider. We replace aggregate labor productivity $\left(\frac{v}{n}\right)$ with nominal gross output per hour in each KLEMS industry (relative to the consumption deflator). We also consider preferences that allow for an industry-specific marginal rate of substitution.[24] The industry-i (intensive-margin) intratemporal wedge is thus

$$\ln\left(\mu_i^{int}\right) = \ln\left(\frac{p_i\, mpn_i^{int}}{p\, mrs_i^{int}}\right) = \ln\left(\frac{p_i \frac{v_i}{n_i}}{p \frac{v}{n}}\right) + \ln\left(\frac{y_i}{v_i}\right) - \frac{1}{\eta}\ln\left(\frac{h_i}{h}\right) + \ln\left(\frac{mpn^{int}}{mrs^{int}}\right).$$

This industry intratemporal wedge differs from the aggregate intratemporal wedge in three possible ways. Value-added per hour could be more or less cyclical in the KLEMS industries than GDP per hour (the first term on the right-side). The cyclicality of gross output may differ from value added (the second term). Finally, hours worked per worker, and thus the mrs, could be more (or less) cyclical for the KLEMS industries (the third term).

Table 8 presents the cyclical elasticities. The KLEMS-industry wedge has a smaller elasticity (-0.89 wrt GDP) than the aggregate IMW (-1.91) from Section 2. Why? Nominal value-added labor productivity is more procyclical in the KLEMS industries than GDP per hour (cyclical elasticity wrt GDP of 0.33), and gross output is more procyclical than value-added (cyclical elasticity wrt GDP of 0.49). Workweeks — which are industry-specific and thus affect the all-industry, manufacturing and non-manufacturing wedges in different ways — account for the remainder.[25]

[24]Preferences are $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_t^{1-1/\sigma}}{1-1/\sigma} - \sum_i \left[\nu \left(\frac{h_{it}^{1+1/\eta}}{1+1/\eta} + \psi \right) e_{it} \right] \right\}$ and thus $\ln\left(\frac{mrs_{it}^{int}}{mrs_t^{int}}\right) = \frac{1}{\eta}\ln\left(\frac{h_{it}}{h_t}\right) + \ln\left(\frac{e_{it}}{e_t}\right)$. In the Appendix we consider alternative preferences, alternative technology (e.g., $\varepsilon \neq 1$), and the *extensive* margin.

[25]Because some of our industries only have workweek data starting in 1990, we use the aggregate average workweek from 1987 through 2012, which had an elasticity with respect to GDP of 0.32 (s.e. 0.03), adjusted by the *relative* elasticity of industry-specific workweeks to the aggregate from 1990 through 2012. These elasticities are 0.32 (s.e. 0.03) for the aggregate, 0.22

Table 8: **Cyclicality of Intensive-Margin Intratemporal Wedge**

	Elasticity wrt	
	GDP	Total Hours
All Industries	-0.89 (0.26)	-0.59 (0.13)
Manufacturing	-0.72 (0.39)	-0.39 (0.20)
Non-Manufacturing	-0.93 (0.24)	-0.65 (0.12)

Note: Each entry is from a separate regression. Annual data from 1987-2012 for 60 industries (1560 industry-year observations), 18 manufacturing and 42 non-manufacturing. All variables in logs and HP filtered. Regressions include industry fixed effects and use industry average value added shares as weights. Standard errors are clustered by year.

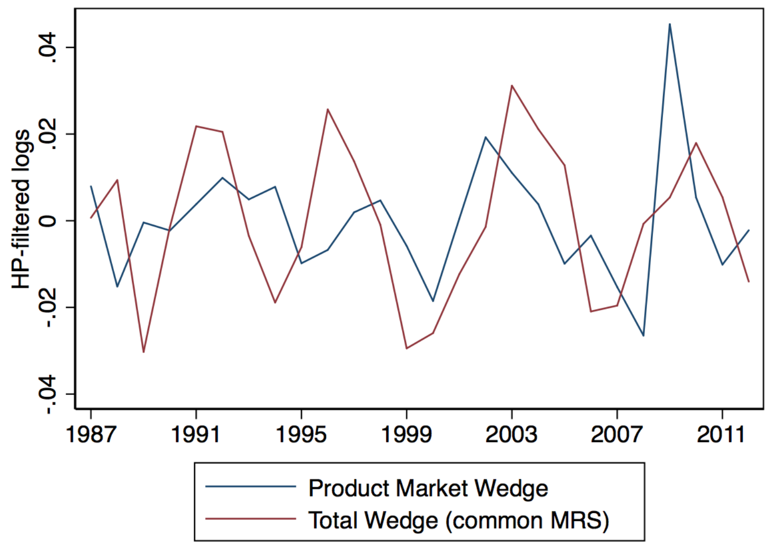
Comparing Tables 7 and 8, the intermediates-based μ^p accounts for essentially all of the cyclical intratemporal wedge. Figure 5 provides visual corroboration by plotting the weighted-average industry (inverse) intermediate share against the intratemporal wedge.[26] This is for the case $\varepsilon = 1$.

When we consider $\varepsilon = 0.5$, μ^p becomes more countercyclical in Table 7. At the same time, a smaller ε makes the intratemporal wedge *less* countercyclical because firms shift away from value-added (labor) in booms. Thus price-cost markups loom even larger relative to the intratemporal wedge if intermediates and value added have more limited substitutability.

(s.e. 0.04) for all KLEMS industries, 0.41 (0.08) for manufacturing KLEMS industries, and 0.16 (0.04) for non-manufacturing KLEMS industries. Appendix Table A1 reports the cyclicality of the intratemporal wedge using a common workweek for all industries (i.e., omitting the industry-specific adjustments).

[26]The intratemporal wedge in Figure 5 is constructed using the aggregate average workweek. Using industry-specific workweeks produces similar plots, just with three fewer years, or 1990-2012.

Figure 5: Intermediates-based μ^p vs. Intratemporal Wedge



5. Discussion and Relationship to Literature

How does our work relate to other attempts at measuring the cyclicality of price markups? The challenge is capturing cyclicality in the marginal cost of production. Researchers must make assumptions about firm production functions in order to infer marginal cost from quantities and prices of inputs and output. Marginal cost should be equated across input margins, so one can consider the cost of marginally increasing output via any input. Many studies have focused on labor — e.g., Bils (1987), Rotemberg and Woodford (1999), and Nekarda and Ramey (2013).

Labor's share of income — the average price of labor divided by its average product — often serves as the baseline measure of marginal cost, with corrections made to address concerns that average prices and products may not equal marginal ones. We argued in Section 2 that using wage data to infer the marginal price of labor may be especially fraught with difficulty, and subsequently eschewed wage data altogether by examining self-employed labor as well as intermediate inputs.

Rotemberg and Woodford (1999) pointed out that one could use intermediate inputs to infer markups. Basu (1995) found that quantities of intermediate inputs rose relative to real output in expansions, but did not explore relative price movements. The work of Murphy, Shleifer, and Vishny (1989), on the other hand, documented relative price movements for broad categories. Their results suggested the relative price of intermediates is likely to be procyclical. By looking at the intermediate share of income, we combine quantities and prices to obtain a measure of marginal cost in Section 4.[27]

Like us, Vaona (2010) uses total intermediate inputs to estimate markups. His sample is 1959-1996 U.S. manufacturing industries, and he estimates the marginal product of intermediates nonparametrically. He emphasizes the response of industry markups to the industry cycle. Our focus is on how average industry markups respond to the emphaggregate cycle. And we provide evidence beyond manufacturing. Kim (2015) estimates markup fluctuations from 1958 to 2009 for manufacturing industries from spending just on energy intermediates. Energy is a fairly small component of our KLEMS intermediates; for 2010, it constituted only 4.4% of total intermediate spending in manufacturing, 6.2% in other industries. For his sample, Kim estimates that markups increase in response to contractionary financial shocks, but are otherwise procyclical. If we similarly consider only energy spending in manufacturing, for our 1987-2012 sample we find energy's share of gross output is procyclical and estimate a countercyclical price markup across a wide range of elasticities of substitution.

Other researchers have also used approaches that do not require wage data. Galeotti and Schiantarelli (1998) measure marginal cost using capital inputs. Like our approach, this requires assumptions on the production function to infer a marginal product (of capital, in this case). In addition, they must take a stand on the stochastic discount factor, because the marginal price (i.e., rental

[27] We also consider a more recent sample and more disaggregated industries.

rate) of capital is not directly observable but depends on both today's acquisition price of capital and tomorrow's expected discounted price.[28] They find evidence of countercyclical markups.

Hall (2014) considers a model in which increased advertising shifts the static demand curve faced by a firm. If the markup is high, then the firm will want to advertise more. The model implies that the ratio of advertising expenditures to revenue is proportional to the markup. Since the advertising expenditure share is acyclical in the data, Hall concludes that markups are also acyclical.

Alternative models of advertising will have different implications for markups. In the Appendix we show that, if advertising affects consumer reservation prices rather than shifting quantity demanded, then changes to the price elasticity of demand have no effect on the advertising expenditure share, but do cause markup changes. A second alteration that breaks the tight contemporaneous link between advertising expenditures and markups is when advertising affects future demand (e.g., Bagwell, 2007). Some evidence that advertising is, at least partially, an investment is provided by Campella, Graham, and Harvey (2010). They report that planned marketing expenditures fell much more for financially constrained firms than unconstrained firms during the Great Recession.[29]

Another approach, pursued by Bils and Kahn (2000) and Kryvtsov and Midrigan (2012), exploits the tight theoretical relationship between markups and finished goods inventories. Consider a firm's decision to add a unit of such inventories. If the additional unit is sold in the current period, the benefit is the markup of price over marginal cost. If the additional unit is not sold, the benefit is the expected discounted ratio of future to current real marginal cost (the firm will not have to acquire the inventory in the future). If the current markup declines, holding all else equal, these prospective benefits are lower —

[28]They incorporate adjustment costs, requiring a further functional form assumption.

[29]Hall (2014) does consider a dynamic model, with an annual depreciation rate of 60 percent for advertising's impact. Because he maintains a constant discount factor, however, there is no channel from high discounting to reduced advertising during the Great Recession.

a lower markup implies a higher real marginal cost — and the firm will reduce its inventories relative to sales.

Note, however, that empirically all else might not be equal. In particular, the appropriate discount rate may vary over the cycle, as may the way in which inventories affect sales. So one must account for both in order to infer markups from inventory data. Importantly, both studies assume $\frac{\partial\ sales}{\partial\ inventories}$ is a time-invariant function of the sales-to-inventory ratio.[30] Given their assumptions and a highly procyclical sales-to-inventory ratio in the data, both studies conclude that markups are countercyclical.

In the Appendix we consider *work-in-process* (WIP) inventories and again infer countercyclical markups. The intuition for the relationship between inventories and markups is similar to that described above. If markups are high (i.e., real marginal costs low) relative to the future, a firm should shift production from tomorrow to today and increase its stock of WIP inventories. The WIP framework is somewhat simpler than that for finished goods: only the relative (inter-temporal) markup appears rather than both the relative markup and the level of the markup. Also, one does not need to take a stand on how inventories affect sales, but instead on how WIP inventories enter the production function.

In summary, these other non-wage approaches to measuring price markups, with the possible exception of Hall (2014), yield results broadly consistent with our own: namely, countercyclical markups. However, they all involve dynamics, requiring one to measure any adjustment costs and the stochastic discount factor. Our self-employed and intermediates approaches, on the other hand, require only static measurements.

[30] Bils and Kahn (2000) assume the elasticity of sales to inventories is constant, while in Kryvtsov and Midrigan's (2012) model, which features demand uncertainty, the probability of a stock-out is a constant function of the ratio of inventories to expected demand. The authors then derive a relationship between the discount factor, sales-to-inventory ratio and markup. If, say, the elasticity of sales to inventories varied over the cycle or there were scale effects of holding finished inventories, then an additional time-varying variable would enter that relationship, and markups could no longer be inferred from observable measures of the discount factor and sales-to-inventory ratio.

6. Conclusion

Hours worked fall more in recessions than can be explained by optimal changes in labor supply in response to real labor productivity. This intratemporal wedge could reflect distortions in the labor market (e.g., sticky wages and matching problems) and/or distortions in the product market (e.g., sticky prices).

Research has increasingly focused on problems in labor markets, in particular for firms hiring workers. Using average hourly earnings, the intratemporal wedge seems to arise between the cost of labor to firms and the value of jobs to workers. But this inference could be mistaken if the true cost of labor to firms is more cyclical than average hourly earnings. If labor's price is measured by the wages of new hires or a user cost of labor, instead of by average hourly earnings, the intratemporal wedge arises as much between the cost of labor and real labor productivity.

To bring new evidence to bear on this debate, we estimated the product market component of the intratemporal wedge without relying on workers' wages. First, we looked at the self-employed. The intratemporal wedge appears nearly as cyclical for the self-employed as for wage earners, even though sticky wages and matching frictions should not be barriers to the self-employed working more hours. The hours of the self-employed appear to fall in recessions because of difficulty, or reluctance, in selling their output (for example due to sticky prices). Second, we presented evidence on intermediate inputs. In recent recessions, output prices rise relative to the level of marginal cost we infer from intermediate prices and quantities. Again, this suggests that firms face difficulty converting production into revenue in recessions. We stress that these two approaches rely on completely different data sources (households vs. industries).

Our point estimates imply that the intratemporal wedge's cyclical variation reflects product market distortions as opposed to labor market distortions. We cannot reject that labor market distortions matter, though they appear less important than has been inferred using data on average hourly earnings. Our evidence is consistent with a price of labor that is at least as cyclical as the new hire wage.

Our evidence does not determine the exact nature of these product market distortions, which is critical for informing stabilization policy. One explanation would be price stickiness that constrains production from translating into added sales. Another would be countercyclical desired markups. (See Rotemberg and Woodford, 1999, for a review.) If producing has an investment component (e.g., the customer base model in Gilchrist et al, 2014), then tightening financial constraints could make firms raise prices relative to marginal cost in recessions as they cut such investments. Our evidence is also consistent with models where expanding production puts firms in a riskier position, and risk (or risk avoidance) heightens during recessions (e.g., Arellano et al, 2012).

Our findings are also relevant for the puzzle of unemployment's high cyclicality relative to labor productivity — the Shimer (2005) puzzle. A highly countercyclical product-market wedge translates into strongly procyclical labor demand, beyond what might be attributed to labor productivity. It provides a rationale for firms to create less employment in recessions without a decline in productivity, and even absent important wage stickiness.

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