Labor Supply Substitution and the Ripple Effect of Minimum Wages

Brian J. Phelan*
DePaul University

December 19, 2013

Abstract

This paper examines the potential causes of the "ripple effect" of minimum wages. This wage spillover is thought to result from labor demand substitution: where the rising minimum increases the demand for more-skilled workers who become relatively inexpensive. However, the rising minimum also affects the relative wages across hedonically distinct occupations because it lowers compensating wage differentials. Thus, the ripple effect may result from declining labor supply at hedonically undesirable occupations. Empirically, I combine panel data on individuals with occupation-level hedonic characteristics and provide evidence that the ripple effect is caused by labor supply substitution and not labor demand substitution.

JEL CLASSIFICATION: J38, J31

Keywords: minimum wage, ripple effect, labor supply, hedonic wages

---

*I would like to thank Robert Moffitt for his help and support with this project. I also thank Matthew Shum, Richard Spady, and seminar participants at the W.E. Upjohn Institute for helpful comments and discussions. Lastly, Nicole Lott provided excellent research assistance with the collection of the O*NET hedonic data. All errors are my own. Address: 1 E. Jackson Blvd, Suite 6200, Chicago, IL 60604. E-mail: bphelan2@depaul.edu

1 Introduction

The minimum wage debate – whether they help or harm low wage workers – remains a contentious issue. Indeed, many studies continue to analyze the employment implications of minimum wage laws on minimum wage workers in order to assess the potential distortions associated with this legislated price floor.[1] This literature, however, has focused much less on an equally important issue: how minimum wages affect other low wage workers.

This paper explores the potential causes of spillovers in the wage distribution that occur when the minimum wage increases. While it has been shown that increases in the minimum wage lead to a positive spillover (or "ripple effect") in wages above the new minimum,[2] there has been few explicit attempts to explain *why* this occurs.[3] This is surprising because the sheer number of individuals affected by the ripple effect is an order of magnitude larger than those being paid the minimum wage.[4] Moreover, understanding why this spillover takes place is an essential first-step before one can address the larger issue of whether this spillover is a "good" or "bad" thing for low-wage workers.

The conventional wisdom is that the ripple effect is due to labor demand substitution, whereby increases in the minimum wage increase the relative price of low-skilled minimum wage workers compared to higher skilled workers.[5] Thus, firms optimally respond to this change in relative prices by substituting away from these less-skilled workers and hiring more skilled workers. This increase in demand for more-skilled workers bids up their wages

[1]For example, some recent studies include: Dube, Lester, and Reich (2010), Allegretto, Dube, and Reich (2011), Hirsch, Kaufman, and Zelenska (2011), Addison, Blackburn, and Cotti (2012), Giuliano (2013), Addison, Blackburn, and Cotti (2013), and Neumark, Salas, and Wascher (2013). Many earlier papers address this issue as well. See, for example: Welch (1974), Brown, Gilroy, and Kohen (1983), Neumark and Wascher (1991), Katz and Krueger (1992), Machin and Manning (1993), Card and Krueger (1994), Neumark and Wascher (1995), Dickens, Machin, and Manning (1999), Machin, Manning, and Rahman (2003), Stewart (2004a), and Stewart (2004b).

[2]See, for example, Gramlich (1976), Grossman (1983), Katz and Krueger (1992), Dickens and Manning (2004), and Neumark, Schweitzer, and Wascher (2004).

[3]Notable exceptions include Flinn (2002) and Flinn (2006).

[4]For example, in this study I find that increases in the minimum increase the wages of all hourly workers making less than twice the minimum wage. In the 2004 SIPP sample, approximately 33% of the labor force aged 15 to 60 are hourly workers paid less than twice the minimum wage. On the other hand, only 3% of workers in the 2004 SIPP are paid between (98% of) the minimum and 5% above the minimum wage.

[5]See, for example, Welch (1974), Gramlich (1976), Grossman (1983), DiNardo, Fortin, and Lemieux (1996), Brown (1999), Teulings (2000), and Neumark, Schweitzer, and Wascher (2004); all of which suggest that labor demand substitution is the cause of the ripple effect.

and leads to the ripple effect. If this well-accepted explanation is true, then the ripple effect is another way in which minimum wage laws may harm those individuals they are intended to help. However, this labor demand response is not the only plausible explanation – even if the low-wage labor market is perfectly competitive.[6]

An alternative and novel explanation is that the ripple effect results from labor supply substitution. According to the hedonic wage model, workers trade off positive job attributes such as location, safety, and cleanliness against the wages they receive. Therefore, the more desirable is a job (e.g. the safer or the cleaner it is), the lower are the expected wages. One implication of the hedonic wage model is that it implies a wage premium associated with negative jobs attributes.[7] Under this framework, an increase in the minimum wage lowers compensating wage differentials for negative job attributes. As compensating differentials fall, the relative wage in more-desirable jobs rises and some workers respond to this change by voluntarily moving to a hedonically more desirable (yet lower paying) job. This falling supply of workers at hedonically undesirable jobs forces these employers to raise their wages – even if they were already above the new minimum.

This supply substitution and rising wage chain reaction is easiest to think about in the context of jobs just above the new minimum where wage premiums over the minimum may be entirely due to compensating wage differentials. For example, suppose the minimum wage had been $8.00 per hour but was just recently raised to $9.00 per hour. Someone working in a meat-processing plant who had been making $9.50 per hour was receiving a $1.50 per hour premium to compensate them for the dirty and dangerous working environment in the plant. After the increase in the minimum, however, that premium shrank to $0.50 per hour. If the plant does not raise its wages, some workers might choose to voluntarily change jobs and seek out a minimum wage job (now paying $9.00 per hour) in a more pleasant and safe

[6]The common finding that employment is not affected by minimum wages has lead researchers to question whether the low-wage labor market is, in fact, a competitive market. See, for example, Lang and Kahn (1998), Flinn (2006), Portugal and Cardoso (2006), Ahn, Arcidiacono, and Wessels (2011), Dube, Lester, and Reich (2011), and Giuliano (2013), who all try to explain the common employment findings with non-competitive models of the labor market. Other papers, such as Aaronson (2001) and Aaronson, French, and MacDonald (2008), do find support for competitive markets.

[7]The hedonic wage model and compensating wage differentials were first suggested by Smith (1776) in chapter 10 of the Wealth of Nations. It was subsequently developed by Rosen (1974) and Rosen (1986), among others.

working environment like a supermarket. Employers at the meat processing plant would optimally respond to this declining labor supply by raises wages at the plant. Thus, the hedonic wage model implies that the ripple effect of minimum wages may also result from labor supply substitution.

These two explanations of the ripple effect – labor demand substitution and labor supply substitution – are not mutually exclusive, and it is possible that both responses play a role in bringing about the ripple effect. Nonetheless, it is important to understand the relative contribution of supply and demand substitution as they imply conflicting stories about the costs and benefits of this spillover to low wage workers. If the ripple effect is purely a result of firms re-optimizing their labor inputs through changes in demand, then the ripple effect harms the least skilled workers through employment declines. On the other hand, if the ripple effect is purely a result of workers re-optimizing their labor supply decisions, then it is more difficult to say that the ripple effect is *a priori* a bad thing for low wage workers because it propagates from optimal reemployment decisions of low wage workers. Moreover, labor supply substitution should not lead to any additional involuntary employment declines. Thus, understanding the true cause of the ripple effect has important policy implications about the benefits of minimum wage laws on low wage workers.

My identification strategy to disentangle these two competing causes in the data builds off of my theoretical model, which implies different patterns of wage and employment adjustments following an increase in the minimum wage. In terms of wages, labor supply substitution implies wage gains for individuals employed at hedonically undesirable occupations while labor demand substitution implies wage gains for higher skilled individuals. In terms of employment, labor supply substitution implies no overall employment losses but a voluntary movement of individuals away from hedonically undesirable jobs and towards hedonically more-desirable jobs. In contrast, labor demand substitution implies involuntary job losses of low skill individuals and voluntary labor market transitions of higher skilled individuals. Thus, the two competing causes can be separately identified by examining how the ripple effect "moves" through the wage distribution and the type of employment response that occurs.

Empirically, I combine data on individuals from the 2004 Survey of Income Program

Participation (SIPP) with data on state-level variation in the minimum wage (between 2004 and 2007) to identify and estimate the ripple effect up to two years after an increase in the minimum wage. I, then, merge in occupation-level hedonic characteristics from the O*NET database (into the SIPP) and develop indices of an occupation's hedonic compensation and an individual's skill premium. These hedonic and skill indices are then interacted with changes in the minimum wage to better understand whether these wage and employment spillovers are associated with the hedonic compensation of an individual's occupation (as implied by labor supply substitution) and/or an individual's skills (as implied by labor demand substitution). In addition to this individual-level analysis, I also examine the employment response within an occupation at the state level. For this analysis, I use state-level employment data from the Current Population Survey to further test whether the individual-level employment responses are evident in more aggregate data. Notably, in both the individual and state-level analysis, the empirical specification is broad enough to test against possible alternative explanations as well.

The empirical results in this paper produce two important findings. First, the ripple effect is more persistent than previously documented and it does not have appear to have the subsequent negative effects that Neumark, Schweitzer, and Wascher (2004) find. Second, the pattern of wage gains and the employment response to changes in the minimum wage are largely consistent with the idea that labor supply substitution is the primary cause of the ripple effect. In fact, there is very little evidence that labor demand substitution (or any other potential cause) plays much of a role at all. These two findings – a more persistent and positive ripple effect combined with the important role of labor supply substitution in bringing about the ripple effect – raise serious doubts about the prevailing view that the ripple effect is per se bad for low wage workers.[8]

2 Related Literature

The existing literature on the ripple effect of minimum wages has largely focused on documenting the magnitude and extent of these spillovers. The empirical methodologies in this

[8]See Neumark, Schweitzer, and Wascher (2004), who conclude accordingly.

literature falls into one of two categories: those that directly estimate these spillovers on individuals using panel data;[9] and those that estimate these spillovers by examining changes in the cross-sectional distribution of wages.[10] This paper follows the individual panel data approach with an empirical methodology that is very similar to Neumark, Schweitzer, and Wascher (2004).

The earliest estimates of the ripple effect, e.g. Gramlich (1976) and Grossman (1983), generally document a fairly small ripple effect. For example, Gramlich (1976) estimates a wage elasticity of 0.027 on non-minimum wage workers. However, this estimate represents the average effect on *all* non-minimum wage workers and thus, the study likely understates the magnitude of these spillovers on lower-wage workers and overstates them on higher-wage workers. This notion is supported by the ripple effect estimates in Katz and Krueger (1992) and Neumark, Schweitzer, and Wascher (2004). Katz and Krueger (1992) estimate a ripple effect wage elasticity of 0.4 on fast-food workers earning just above the new minimum.[11]

Neumark, Schweitzer, and Wascher (2004) take a broader approach and estimate the ripple effect over twelve non-linear wage intervals using the matched CPS, where ripple effects are estimated on individuals grouped by their wage relative to their state's minimum wage, ($\frac{W_{is}}{MW_s}$). This approach allows them to differentiate between the effects of changes in the minimum wage at different points in the wage distribution. They document a non-linear ripple effect that extends far into the wage distribution. They estimate a wage elasticity of 0.8 for workers paid just above the minimum, but that elasticity falls to 0.25–0.40 for workers paid between 1.1 and 1.5 times the minimum. Moreover, it falls farther to 0.06 for individuals paid between two- to three-times the minimum wage.[12] Interestingly, Neumark, Schweitzer, and Wascher (2004) also document that while wages tend to increase in the first

[9]See, for example, Gramlich (1976), Grossman (1983), Katz and Krueger (1992), Neumark, Schweitzer, and Wascher (2004), and Wicks-Lim (2006)

[10]See, for example, Lee (1999), Dickens and Manning (2004) and Flinn (2002). A handful of other studies use the overall distribution of wages to analyze the employment implications of minimum wages (see Meyer and Wise (1983) and Dickens, Machin, and Manning (1998)) and the effects of minimum wages on the wage structure (see DiNardo, Fortin, and Lemieux (1996), Lee (1999)), and Autor, Manning, and Smith (2010).

[11]This elasticity is calculated by the author from the estimates of the wage effects in their Table 3 of Katz and Krueger (1992).

[12]Neumark, Schweitzer, and Wascher (2004) also document positive ripple effects on individuals paid 5 to 8 times the minimum wage, but surprisingly no (immediate) effect on individuals paid 3 to 5 times the minimum wage.

year after the minimum wage increases, wages often fall in subsequent years to the point where the net effect (associated with the two years) is often negative. Thus, they conclude that this spillover "most likely reduce[s] the well-being of low-wage workers."

This paper contributes to this literature by explicitly addressing the issue: why does the ripple effect occur. In this capacity, I present an alternative theoretical justification for the ripple effect, labor supply substitution, and then execute an empirical strategy that separately identifies the two competing causes: labor supply substitution and labor demand substitution. In the process of assessing these competing causes, I re-estimate the ripple effect using the SIPP, a longer panel than the 2-year data used by Neumark, Schweitzer, and Wascher (2004). This longer panel proves to be quite useful in re-examining the finding in Neumark, Schweitzer, and Wascher (2004) that the ripple effect is characterized by wage losses in the lagged year after the minimum wage increases.

3 The Model

The extended hedonic wage model, where wages are a function of both individual skills (S_i) and the hedonic characteristics of an occupation (Z_k), is easily extended to show the existence of the ripple effect and elucidate its potential causes. Let wages for an individual, i, working at some occupation, k, be:

$$W_{ik} = f(S_i, Z_{1k}, Z_{2k}, ..., Z_{nk}) \text{ with } \frac{\partial W_{ik}}{\partial S_i} \geq 0 \text{ and } \frac{\partial W_{ik}}{\partial Z_{lk}} \leq 0 \quad \forall l \tag{1}$$

where S_i represents an individual's skill and each Z_{lk} represents a positive job characteristic (indexed by l) at occupation k. Wages in this model are an increasing function of an individual's skills but a decreasing function of the overall quality (or desirability) of one's occupation. Hence, favorable working characteristics attract labor at lower than average wages while jobs with unfavorable working conditions pay offsetting wage premiums (or "compensating differentials") to attract workers, as expressed in Rosen (1986).

Suppose further that an individual's utility is a function of consumption of both market goods (C_i) and job attributes (Z_k), where the consumption of market goods is constrained by (and thus, a function of) wages, $C_{ik} = \gamma(W_{ik})$. Then, the individual's objective function can be expressed as:

$$\max U_{ik} = U_i(C_{ik}, Z_{1k}, Z_{2k}, ..., Z_{nk}) \text{ where } \frac{\partial U_{ik}}{\partial C_{ik}} \geq 0 \text{ and } \frac{\partial U_{ik}}{\partial Z_{lk}} \geq 0 \quad \forall l \tag{2}$$

This set-up is common in the hedonic model and implies that workers trade-off positive job attributes and wages to maximize utility. For expositional purposes, however, I simplify the model and assume that there are only two skill levels and all occupations can be classified by a single hedonic characteristic, danger, which also takes one of two values. Thus, all individuals are either low skill ($S_i = 0$) or high skill ($S_i = 1$); and all jobs are either dangerous ($Z_k = 0$) or safe ($Z_k = 1$).[13]

This extended hedonic framework is rich enough to show that the ripple effect may result from either labor supply substitution or labor demand substitution. To illustrate these implications one must simply fix either the skill-level of individuals or the hedonic characteristics across jobs. Labor supply substitution results from fixing the skill level of individuals, while labor demand substitution results from fixing the hedonic characteristics across jobs.

3.1 Supply Substitution

Suppose all worker have the same skills ($S_i = \bar{S}\ \forall i$). Then,

$$W_{\bar{S},Z_k} = \begin{cases} W_{\bar{S},1} & \text{if i chooses the safe job} \\ W_{\bar{S},0} & \text{if i chooses the dangerous job} \end{cases} \tag{3}$$

where $W_{\bar{S},0} > W_{\bar{S},1}$ because of the compensating wage differential for danger.

For a given level of consumption ($\bar{C}$), it follows that $U(\bar{C}, 1) > U(\bar{C}, 0)$. However, because wages vary between the two jobs, the consumption level of individuals employed in the risky job is greater than the consumption of individuals in the safe jobs (conditional on skills), i.e. $C_0 > C_1$ where $C_1 = \gamma(W_{\bar{S},1})$ and $C_0 = \gamma(W_{\bar{S},0})$. Thus, if $U_i()$ is continuous,

[13] This simple two sector set-up is only a minor extension of the two sector set-up laid out in Rosen (1986).

there exists some level of consumption associated with the dangerous job for each individual, C_i^*, such that the individual is indifferent between the dangerous job and the safe job, i.e. $U_i(C_1, 1) = U_i(C^*, 0)$. If the required level of consumption from the dangerous job is greater than the actual level of consumption with the dangerous job, $C_i^* > C_0$, the additional utility associated with the additional consumption (from being employed at the risky job) does not outweigh the disutility of being at the risky job. Thus, the individual optimally chooses the safe job. If, on the other hand, $C_0 > C_i^*$, then the opposite is true and the individual optimally chooses the dangerous job.

This set-up leads to a ripple effect of minimum wages if the wage for the safe job, $W_{\bar{S},1}$, is less than the new minimum wage. When the minimum increases, $W_{\bar{S},1}$ increases because of the binding minimum wage. Then, by definition, C_1 increases, but so does C_i^*. This rising opportunity wage in the "safe" sector causes some individuals to optimally re-allocate their labor supply to "safe" jobs and the declining supply bids up wages in the "dangerous" sector.

Proposition 1. *If all workers have the same level of skill ($\bar{S}$) and the government imposes a binding minimum wage (MW) such that $MW > W_{\bar{S},1}$ but $MW < W_{\bar{S},0}$, then wages for both the safe and the dangerous job will rise.*

Proof. Trivially, $W_{\bar{S},1}$ must rise to MW because by assumption the minimum wage is binding. To show that $W_{\bar{S},0}$ must also rise, recall that a worker chooses to work in the dangerous section if and only if $U_i(C_1, 0) \geq U_i(C_1, 1)$. If, $W_{\bar{S},1}$ increases $\Rightarrow C_1$ increases $\Rightarrow U(C_1, 1)$ increases. Thus, the number of people willing to accept the dangerous job declines, shifting the labor supply curve back. If the demand for labor is fixed, $W_{\bar{S},0}$ must rise. [14] □

This simple two-job setup and all of its implications extend to more-realistic specifications with continuous hedonic measures and more hedonic characteristics. Thus, the hedonic approach shows that workers within a skill group respond to changes in the minimum wage through their labor supply decisions in a way that would bring about the ripple effect.

[14] Since we are talking about similarly skilled employees, there is no reason the expect the demand curve to shift. As I explain below in Section 3.2, the demand for labor will only shift if the employer demands differently skilled employees. But even under those condition, demand increases for all but the lowest skilled workers. Thus, stable demand is a conservative assumption among low skill workers.

3.2 Demand Substitution

The extended hedonic wage model also implies that the ripple effect results from labor demand substitution. Suppose that all jobs have the same hedonic characteristics, i.e. $Z_k = \bar{Z}\ \forall k$, but there are two types of workers, low skill workers ($S_i = 0$) and high skill workers (S_i=1). Firms produce output (y) using a combination of low skill labor (L_0) and high skill labor (L_1) and maximize profit given competitively determined wages. Thus, the firm's objective function is:

$$\max \Pi = P_y g(L_0, L_1) - W_{0,\bar{Z}} L_0 - W_{1,\bar{Z}} L_1 \tag{4}$$

Workers are paid their marginal revenue product, i.e. $W_{1,\bar{Z}} = P\frac{\partial g}{\partial L_1}$ and $W_{0,\bar{Z}} = P\frac{\partial g}{\partial L_0}$, where skilled labor is more productive and thus higher paid. If all of the standard conditions hold for the production function, i.e. $\frac{\partial g}{\partial L_j} \geq 0$, $\frac{\partial g^2}{\partial^2 L_j} \leq 0$, and $\frac{\partial g}{\partial L_1 \partial L_0} \geq 0$ for $j \in \{0,1\}$, then the labor demand function for each type of labor is a function of both the skilled and unskilled wage rate where $\frac{\partial L_j^*}{\partial W_j} < 0$ and $\frac{\partial L_j^*}{\partial W_{-j}} > 0$.[15] Thus, a rise in the minimum wage, which increases W_0, also increases the demand for skilled labor, L_1, and wages for skilled labor, W_1.

Proposition 2. *If all jobs have the same hedonic characteristics and the government imposes a binding minimum wage (MW) such that $MW > W_{0,\bar{Z}}$ but $MW < W_{1,\bar{Z}}$, then the wages for both the low skill and the high skill job will rise.*

Proof. Trivially, $W_{0,\bar{Z}}$ must rise to MW because the minimum wage is binding. However, because $W_{0,\bar{Z}}$ rises and firms hire L_0 until $P\frac{\partial g}{\partial L_0} = W_{0,\bar{Z}}$, L_0 declines. Since L_0 declines, $\frac{\partial g}{\partial L_1}$ declines because $\frac{\partial g}{\partial L_1 \partial L_0} \geq 0$. But, it is optimal to hire labor until $W_{1,\bar{Z}} = P\frac{\partial g}{\partial L_1}$. If $\frac{\partial g}{\partial L_1}$ declines, then optimal L_1 increases because $\frac{\partial g^2}{\partial^2 L_1} \leq 0$. As demand for skilled labor increase, $W_{1,\bar{Z}}$ also increases. □

Similar to the labor supply story, this simple two-skill setup and all of its implications extend to more-realistic specifications with continuous skill measures as well as multidimensional skills. Hence, the model implies that the ripple effect can also result from labor demand substitution.

[15] For example, if $g(L_0, L_1) = L_0^{\alpha} L_1^{1-\alpha}$, then $L_1^* = \bar{Y}\left[\frac{(1-\alpha)W_0}{\alpha W_1}\right]^{\alpha}$ for some level of production, $\bar{Y}$. Clearly, $\frac{\partial L_1^*}{\partial W_1} < 0$ but $\frac{\partial L_1^*}{\partial W_0} > 0$.

3.3 Model Summary

The extended hedonic wage model demonstrates that the ripple effect may result from two distinct causes: labor supply substitution from similarly skilled workers responding to a rising opportunity wage at hedonically more desirable jobs, and labor demand substitution from firms responding to a falling relative price of skilled labor. It is possible that both labor supply and labor demand responses are taking place, and thus it remains an empirical question as to which cause best explains why we observe the ripple effect of minimum wage laws.

In the sections that follow I use the intuition of this extended hedonic model to develop and execute an empirical strategy that separately identifies the effect of labor supply and demand substitution on the propagation of the ripple effect. Specifically, I interact estimates of occupation-level hedonic compensation and individual skill premiums with changes in the minimum wage to understand how the ripple effect "moves" through the wage distribution. A ripple effect that increases the wages of individuals at hedonically less desirable jobs (conditional on skills and wages) is consistent with labor supply substitution while a ripple effect that increases the wages of individuals with higher skills (conditional on hedonics and wages) is indicative of labor demand substitution.

Moreover, these potential shifts in labor supply and labor demand also imply very different effects on employment levels. Thus, I also analyze the employment response to changes in the minimum wage to better understand the underlying cause of the ripple effect. Supply substitution implies employment changes across occupations with declining employment at hedonically undesirable jobs and increasing employment at hedonically desirable jobs. On the other hand, demand substitution implies employment changes within occupations where the mix of workers within an occupation becomes more skilled when the minimum increases.

4 The Data

To estimate the ripple effect and better understand it's underlying causes, I use data on the labor market experiences of individuals from the 2004 Survey of Income Program Participation (SIPP), data on occupation-level hedonic characteristics from the O*NET database, and aggregated state-level data on occupational employment from the Current Population Survey (CPS). The following section briefly describes these data sources and the specific variables I use in my empirical analysis.

4.1 Survey of Income Program Participation

The primary data source I use in this analysis (to evaluate individual-level wage and employment adjustments to the minimum wage) is the 2004 SIPP. The 2004 SIPP surveyed approximately 43,500 households over a period of 32 to 48 months between January 2004 and December 2007.[16] This survey is an excellent source to understand the extent of the ripple effect and test for its potential causes due to its large nationally representative sample, the panel nature of the labor market data, and the fact that there were numerous state-level adjustments in the minimum wage over the period of collection.

Each member of each participating household was surveyed every 4 months and asked a range of questions about their labor market participation over the previous 4 months. Of the approximately 43,500 households that begin in the sample, I focus on 34,881 individuals who were aged 16 to 60 during the survey, were employed for at least two consecutive years, and whose first period wage (in the SIPP) was between the minimum wage and six times the minimum wage.[17]

The summary statistics of this sample are presented in Table 1. Consistent with what one might expect: hourly and low-wage workers are generally younger, less experienced, more likely to voluntarily change jobs, and more likely to experience an involuntary transition due to a "layoff" or being "fired."[18] Moreover, it is reassuring that the summary statistics of the

[16]The survey was originally supposed to cover 48 months for all households, but due to budget shortfalls at the Census Bureau, it was scaled back after 32 months and half of the remaining households were discontinued at that point in mid-2006. See http://www.census.gov/sipp/usrguide.html, Chapter 2, at pp.2.

[17]Individuals earning less than the minimum wage were excluded from the analysis because they likely experience additional compensation (e.g. tips for waiters) that is not included in wages – though, I actually keep any individual being paid at least 0.98*MW to account for some measurement error. Individuals earnings more than six times the minimum wage were excluded because the sample sizes were very small.

[18]A "low wage" worker for these summary statistics is an individual paid less than twice the minimum wage.

full sample and those experiencing a change in the minimum wage have very similar mean values. This similarity lends credence to the idea that changes in the minimum wage are exogenous wage shocks. I discuss the importance of this assumption in more detail below.

Table 1: Summary Statistics

	All Individuals	Hourly Workers	Low-Wage Workers	All Individuals ΔMW > 0	Low-Wage Workers ΔMW > 0
	(a)	(b)	(c)	(d)	(e)
Female	0.51	0.52	0.58	0.52	0.57
Non-White	0.19	0.21	0.23	0.18	0.21
Age	36.4	34.8	31.5	36.2	31.1
Years of Education	13.2	12.6	12.1	13.3	12.2
Firm-Level Tenure	1.7	1.4	0.9	1.7	0.9
Probability of Voluntary Transitions	0.26	0.31	0.41	0.27	0.42
Probability of Involuntary Transition	0.09	0.11	0.13	0.10	0.14
Hourly Wage	15.2	13.0	8.8	15.8	9.4
N	34,881	23,823	14,742	12,229	5,194

Notes: N is the total number of individuals - not the number of observations. "Low-Wage" workers are workers paid less than twice the minimum wage. The last three variables use all observations from each individual, while the first five simply use an individual's first observation.

4.2 The O*NET and Hedonic Wage Premium

The hedonic characteristics of occupations come from the U.S. Department of Labor's O*NET database. The O*NET collects extensive occupation-level data on the characteristics of occupations including the tasks performed, the skill requirements to perform a job, and the hedonic characteristics of the occupation. For this analysis, I focus on the following eight hedonic measures: "Cramped Work Space, Awkward Positions," "Exposed to Hazardous Conditions," "Exposed to Hazardous Equipment," "Exposed to Minor Burns, Cuts, Bites, or Stings," "Spend Time Kneeling, Crouching, Stooping, or Crawling," "Very Hot or Cold Temperatures," "Wear Common Protective or Safety Equipment," and "Exposed to Contaminants." Each of the these hedonic variables is assigned a value from 1 to 5 to capture the severity of these hedonic characteristics at each occupation in the O*NET, where 5 is the most severe. The O*NET occupations are then converted into the 503 occupation codes from the SIPP.[19]

[19] The O*NET occupations are actually more-disaggregated than the 3-digit SOC, which are more disaggregated that than the SIPP occupation codes. Thus, hedonic values were averaged across O*NET occupations within an SOC occupation, and hedonic values were again averaged (weighted by employment levels) across SOC occupations within a SIPP occupation.

Rather than focus on any one of these hedonic characteristics, I estimate the implied hedonic wage premium associated with all eight measures and use the estimated hedonic premium as a measure of the overall desirability (or undesirability) of an occupation. Specifically, I estimate the following equation:

$$\ln W_{ikst} = \alpha + \alpha_s + \alpha_t + \beta X_{ist} + \delta Z_k + \epsilon_{ist} \tag{5}$$

using OLS after merging in the occupation-levels hedonic characteristics from the O*NET into the SIPP. In this expression, α_s and α_t are state and year fixed effects, X_{ist} is a vector of individual controls such as education and experience,[20] and Z_k are the eight hedonic intensities at occupation k. The combined hedonic wage premium associated with an occupation (H_k) is simply the predicted wage premium associated with the eight O*NET hedonic variables in equation (5):

$$H_k = \hat{\delta} Z_k$$

Positive predicted values imply that the occupation has net undesirable qualities that require positive wage offsets while negative values imply that the occupation has net desirable job attributes that require workers to give up some portion of their pay to work in this occupation.

These estimates of the hedonic wage premium are likely to be biased due to the endogeneity of hedonic characteristics – where it is well-accepted that higher skilled (and thus higher paid) individuals tend to demand better working conditions.[21] This bias should understate the true hedonic compensation associated with hedonic characteristics. However, there is little reason to believe that these biases will be systematic in any way that alters the relative hedonic compensation across occupations, which is precisely how I use these hedonic compensation measures. Thus, for this analysis it is not problematic if the estimates

[20] A complete list of the controls I use in estimating this equation are: years of education, years of implied experience (and square term), years of firm-level tenure (and square term), sex, race, union membership, an indicator for whether an individual was in school or not, an indicator for whether the individual experienced a layoff (or was fired), an indicator if the individual moved, and an indicator if the individual switched compensation from being an hourly worker to a salaried worker (and vice versa).

[21] Indeed, the empirical literature estimating hedonic wage premiums has generally estimated hedonic coefficients that are the "wrong" sign. See, for example, Brown (1980) and Rosen (1986).

are biased, so long as the relative ordering (and magnitudes) are not biased. Nevertheless, I address this concern by estimating equation (5) separately for different wage groupings, where (like the ripple effect estimates) individuals are grouped by the relative value of their wage to their state's minimum wage.[22] This segmentation should minimize the bias in the hedonic coefficients because they are then estimated separately for different skill groupings.

Despite these endogeneity concerns, the combination of these 8 hedonic variables largely captures what one would expect in terms of the *relative* hedonic compensation across occupations. For example, the estimates imply that some of the largest hedonic wage premiums are earned by chemical engineers, pilots, hazardous waste removers, and nuclear technicians. On the other hand, the smallest (i.e. largest negative) hedonic wage premiums are earned by non-farm animal caretakers, child care workers, postal workers, and counter clerks. A list of the 20 highest- and lowest-hedonically compensated occupations – for all workers and all low-wage workers – is presented in Table A1 in the appendix. Moreover, the hedonic compensation coefficients from equation (5) are presented in Table A2.[23]

4.3 Measuring Skill

I also use a subset of the estimated β-coefficients from equation (5) to estimate an individual's skill premium. Specifically, an individual's skill premium (E_{it}) is the predicted value associated with an individual's education and labor market experience (firm-level experience and total implied experience). Thus,

$$E_{it} = \hat{\beta}_1 Exp_{it} + \hat{\beta}_2 ExpSq_{it} + \hat{\beta}_3 FirmTenure_{it} + \hat{\beta}_4 FirmTenureSq_{it} + \hat{\beta}_5 YrsEdu_{it}$$

where the $\hat{\beta}$-coefficients are from the estimation of equation (5). To avoid endogeneity concerns associated with changing skill prices following an increase in the minimum wage, I use an individual's first employed observation in the SIPP panel to estimate their skill premium (i.e E_{i1}) and then hold this value fixed over the panel for each individual.

[22] The wage groupings I use are identical to the wage groupings in my 4 interval ripple effect estimates: $W < 1.15MW$, $1.15MW \leq W < 1.75MW$, $1.75MW \leq W < 2.25MW$, and $2.25MW \leq W < 6MW$.

[23] The subsequent estimates in the paper are qualitatively the same if I use a single equation to estimate H_k.

4.4 Current Population Survey

The last major data source I use in the empirical analysis is the Current Population Survey (CPS). I utilize this large nationally representative sample of the U.S. labor market to understand how state-level occupational employment changed following state-level increases in the minimum wage. Did employment decline at hedonically undesirable jobs (and increase at hedonically desirable jobs) as predicted by supply substitution? Did higher skilled workers become a larger share of those employed within occupations as predicted by demand substitution? While the CPS is a cross-sectional data source, I use it to create a panel of state-level occupational employment over the period 2004 to 2007.

Like the individual analysis, I focus on individuals age 16 to 60 who were employed (but not self-employed) during the period of analysis. Different from the individual analysis, I focus on a slightly broader group of individuals than in the SIPP – those earning at least 80% of the minimum and not more than ten times the minimum – because a broader range of observations increases the number of individuals making up each state-level total. This gives me a sample of about 80,000 individuals in each of the four years.[24] While this might be considered a large sample in many contexts, it is not in this context. Indeed, once these 80,000 observations are split across 51 states (including D.C.) and 503 occupations, the resulting occupation-state characteristics are often based on very small samples. For this reason, I aggregate occupations with similar hedonic compensation for the hedonic analysis and aggregate occupations with similar average skill premiums for the skill analysis. This aggregation is described in detail below.

4.5 Minimum Wages

Lastly, I use state-level minimum wage data from the U.S. Department of Labor's website.[25] As shown in Table A3 in the Appendix, there were a large number of changes in state-level minimum wages over this period (2004-2007). Indeed, more than a third of all individuals in the SIPP experienced a change in the minimum wage at some point during the panel.

[24] The exact number of observations per year is 80,289 from 2004, 78,907 from 2005, 79,008 from 2006, and 78,200 from 2007.

[25] See http://www.dol.gov/whd/state/stateMinWageHis.htm, last accessed 9/28/12.

Some of this prevalence is due to the increase in the federal minimum wage in July 2007, but more than 90% of the observations with changes in the minimum wage occurred at the state-level before the change in the federal minimum wage.

5 Estimating the Ripple Effect

The empirical portion of the paper consists of two main parts. First, I re-estimate the ripple effect using the SIPP. Second, I use the implications of my extended hedonic model to analyze the extent to which the ripple effect is due to labor supply and/or labor demand substitution. To this end, I analyze the distinct patterns of wage and employment changes following an increase in the minimum wage – in particular, the extent to which they are associated with the hedonic characteristics of an occupation versus the skills of an individual. Thus, I first develop my baseline estimation strategy of the ripple effect and describe the results. I then extend that methodology to examine these distinct empirical patterns in wages and employment to distinguish between labor supply and labor demand substitution in the data.

5.1 Empirical Strategy

The ripple effect is estimated by regressing the change in an individual's wage on the change in their state-level minimum wage and other controls associated with wage growth. Following the lead of Neumark, Schweitzer, and Wascher (2004), I estimate the ripple effect over a series of non-linear wage intervals where individual's are grouped by their wage relative to their state's minimum wage. This flexible non-linear specification allows changes in the minimum wage to have different effects on wages at different points in the wage distribution. I focus on the following eight wage intervals: $MW \leq W < 1.05MW$, $1.05MW \leq W < 1.15MW$, $1.15MW \leq W < 1.5MW$, $1.5MW \leq W < 1.75MW$, $1.75MW \leq W < 2MW$, $2MW \leq W < 2.5MW$, $2.5MW \leq W < 4MW$, and $4MW \leq W < 6MW$;[26] which are

[26] These intervals differ slightly from Neumark, Schweitzer, and Wascher (2004) for two reasons. First, the sample in the SIPP is smaller than the MORG and thus, I cannot precisely estimate the effect over 12 intervals as they did. Second, the number of individual's being paid more than six times the minimum wage was quite small in my sample and thus, it did not make sense to extend all the way to eight times

captured by a vector of indicator variables, $R(W_{is}^1, MW_s^1)^j$, which contains an indicator for each of the j wage intervals. Thus, $R(W_{is}^1, MW_s^1)^1$ takes the value of 1 if an individual's first period wage (W_{is}^1) was greater than the minimum wage (MW_s^1) in his state (during that year), but was less than five percent above the minimum wage at that time.[27]

The ripple effect is estimated using the following specification:

$$\begin{aligned}\ln W_{ist}^p - \ln W_{is}^1 =& \alpha + \alpha_s + \alpha_t + \sum_{z=-2}^{1} \sum_{j=1} \beta_j^z \Delta \ln MW_{s,t+z} * R(W_{is}^1, MW_s^1)^j \\ &+ \sum_{j=1} \phi_j \ln W_{is}^1 * R(W_{is}^1, MW_s^1)^j + \sum_{j=1} \psi_j (p-1) R(W_{is}^1, MW_s^1)^j \\ &+ \sum_{j=1} \gamma_j R(W_{is}^1, MW_s^1)^j + \delta X_{ist} + \epsilon_{ist}\end{aligned} \tag{6}$$

where W_{ist}^p is an individual's wage in state s, year t, and period p; where $p \in \{2, 3, 4\}$ represents the number of years (or periods) since an individual's first employed observation (i.e. when $p = 1$). An individual's period, p, differs from the year, t, because a small minority of individuals in the sample (4.4%) were not employed in 2004, the first year of the 2004 SIPP, but subsequently became employed.

The ripple effect estimates are the β_j^z coefficients in (6), which are associated with the interaction of the one year change in the log minimum wage ($\Delta \ln MW_{s,t+z}$) in state s and the non-linear wage interval indicator, $R(W_{is}^1, MW_s^1)^j$. Thus, there is a separate ripple effect estimate for each of the j wage intervals. The ripple effect is also estimated for each of the z periods, which include the leading effect one year before the change ($z = 1$), the current effect ($z = 0$), and lagged effects both one year after ($z = -1$) and two years after ($z = -2$) the change in the minimum wage.

This ripple effect specification also includes the wage interval indicator, $R(W_{is}^1, MW_s^1)^j$, interacted with an individual's first-period wage, interacted with the number of years since the first period, and included by itself. These three sets of variables address the fact that wage growth is likely to have different intercept and slope effects at different points in

the minimum as they did. However, estimates that extend the last wage interval to 8*MW are essentially identical to what I present.

[27] Individual's earning less than 0.98*MW are excluded because these individuals are likely experiencing additional compensation (e.g. tips for waiters) that is not included in wages.

the wage distribution and over time. Lastly, this specification also includes state (α_s) and year (α_t) fixed effects as well as common demographic and individual controls, X_{ist}.[28] All estimates use sampling weights from the SIPP and standard errors are clustered at the state level. Lastly, I exclude all observations where the average year-over-year change in wages exceeded ± 0.3 log points (or approximately ± 30%). These outlier observations were excluded because these large wage changes add a lot of noise to the estimation and they are presumed to occur for reasons other than the change in the minimum wage.[29]

Generally, this specification is very similar to Neumark, Schweitzer, and Wascher (2004), where the β-coefficients can be interpreted as elasticity measures. One area where it differs is that wage growth and the grouping of individuals to wage intervals is based upon an individual's first period wage – rather than an individual's lagged wage. This difference is based in part on the data I am using in this analysis, which is a longer panel than the matched CPS, which was used by Neumark, Schweitzer, and Wascher (2004). However, this strategy of anchoring an individual's wage to an earlier wage also allows me to estimate a more accurate lagged ripple effect. This point is described in more detail below.

As in Neumark, Schweitzer, and Wascher (2004), I also estimate the ripple effect of minimum wages on weekly hours of work (and weekly earnings) because employers may respond to the rising wages with diminished employment. The empirical specification for this is almost identical to equation (6) except that the dependent variable is now the log change in weekly hours of work (weekly earnings) and the specification includes the logarithm of an individual's initial weekly hours of work (weekly earnings) as an explanatory variable.

5.1.1 Identification of the Ripple Effect

The ripple effect is identified using variation in the timing and magnitude of changes in the state-level minimum wage. These estimates capture the causal effect of the minimum wage on other wages if the changes in the minimum wage are exogenous to other unobserved

[28] These individual controls include years of education, implied labor market experience, firm-level tenure, sex, race, a union membership indicator, an indicator if the individual was in school or not, an indicator if the individual experienced a layoff or was fired, an indicator if the individual quit their job, an indicator if the individual moved, and an indicator if the individual switched compensation from being an hourly worker to a salaried worker (or vice versa).

[29] This exclusion leads to an 11% decline in the number of observations for hourly workers.

factors affecting an individual's wage growth, such as the overall health of the economy in the state. This is a common assumption in the literature, and one that I assume for this analysis. However, it is possible that changes in the minimum wage are only politically palatable during periods of economic growth when wage growth is to be expected anyway. While this specification includes state and year fixed effects, if there is a great deal of state-level variation in economic activity over time that is correlated with changes in the minimum, then the estimates of (6) will overstate the true ripple effect.

5.2 Estimates of the Ripple Effect

The ripple effect estimates are presented in Table 2. As shown therein, the ripple effect is evident among individuals in the SIPP. Columns (a)-(d) present results for hourly workers broken out by wage groupings and over time – where "T" refers to the period just after the minimum increases, T+1 (T+2) refers to one (two) year after the increase, and T-1 refers to one year prior to the increase.

As mentioned above, the coefficients can be interpreted as elasticities. Thus, the results imply that workers earning less than 5% above the minimum (in the initial SIPP period) experience additional wage growth of about 6% immediately following a 10% increase in the minimum wage. This increase in wages may seem smaller than one might expect since these are essentially minimum wage workers, but there are two mitigating factors worth considering. First, the control group is other minimum wage workers that did not experience an increase in the minimum wage. Since these workers are also likely to experience wage growth, the estimates in Table 2 capture the *additional* wage growth to hourly workers in states that do increase the minimum wage. Second, the wage groupings in the estimation of equation (6) are based on an individual's wage in the first observation in the SIPP panel. This structure will lead to a downward bias in the ripple effect estimates since an individual earning less than five percent above the minimum in the first period may be earning quite a bit more a year or two later when the minimum increases. Thus, taken together, the 0.57 estimate in the immediate period following the increase in the minimum wage (i.e. period "T") seems reasonable and comparable with past estimates. Interestingly, one year after the hypothetical 10% increase in the minimum, the estimates imply that these workers continue to earn 7% more than workers in states that did not increase the minimum. This wage premium disappears for these low wage workers two years after the increase.

Table 2: The Ripple Effect of Minimum Wages by Wage Grouping

	Employees Paid Hourly				All Employees			
Wage Grouping	**T-1**	**T**	**T+1**	**T+2**	**T-1**	**T**	**T+1**	**T+2**
	(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**
$mw \leq w < 1.05 * mw$	0.17**	0.57***	0.72***	-0.01	0.11	0.58***	0.72***	0.01
	(0.07)	(0.08)	(0.21)	(0.08)	(0.07)	(0.10)	(0.21)	(0.09)
$1.05 * mw \leq w < 1.15 * mw$	0.17**	0.17	0.52***	0.34***	0.17*	0.23**	0.49***	0.30***
	(0.08)	(0.11)	(0.18)	(0.09)	(0.09)	(0.11)	(0.16)	(0.10)
$1.15 * mw \leq w < 1.5 * mw$	0.03	0.18***	0.20***	0.17**	0.01	0.18***	0.16***	0.07
	(0.03)	(0.04)	(0.06)	(0.07)	(0.03)	(0.04)	(0.05)	(0.06)
$1.5 * mw \leq w < 1.75 * mw$	-0.02	0.09*	0.17**	0.09	-0.06	0.04	0.16**	-0.05
	(0.03)	(0.05)	(0.07)	(0.10)	(0.03)	(0.04)	(0.06)	(0.08)
$1.75 * mw \leq w < 2 * mw$	0.02	0.08	0.20**	0.22*	0.01	0.03	0.11	0.10
	(0.05)	(0.11)	(0.08)	(0.12)	(0.05)	(0.10)	(0.08)	(0.11)
$2 * mw \leq w < 2.5 * mw$	0.00	-0.03	-0.02	0.21	-0.02	0.01	0.04	0.03
	(0.04)	(0.06)	(0.07)	(0.13)	(0.03)	(0.04)	(0.12)	(0.10)
$2.5 * mw \leq w < 4 * mw$	-0.01	0.02	0.05	0.22*	-0.03	-0.03	-0.07	0.11
	(0.04)	(0.04)	(0.08)	(0.13)	(0.03)	(0.03)	(0.06)	(0.07)
$4 * mw \leq w < 6 * mw$	-0.02	-0.02	-0.03	-0.46*	-0.03	-0.01	0.02	-0.30***
	(0.03)	(0.08)	(0.10)	(0.24)	(0.04)	(0.04)	(0.05)	(0.08)

Notes: The ripple effect is estimated as the elasticity of wages following an increase in the minimum wage. Standard errors were clustered at the state level and sample weights were used in the estimation. Period T refers to the period just following the increase in the minimum wage; T-1 is 1 year prior to the increase; T+1 (T+2) is 1 year (2 years) after the increase.

Consistent with past estimates of the ripple effect, the results in Table 2 demonstrate that other individuals – those earning well above the minimum – also experience wage gains when the minimum increases. The results indicate that a 10% increase in the minimum wage leads workers earning 5%-15% above the minimum to experience relative wage growth of 2% one year prior to the increase and his differential increases to 5% one year after the increase and remains 3% above workers in other states even two years after the change. Similarly, a 10% increase in the minimum wage leads workers being paid 15%-50%, 50%-75%, and 75%-100% above the minimum to experience relative wage growth of about 2% that persists even two years after the minimum wage increases. There is little evidence that the minimum wage affects workers being paid more than twice the minimum wage.

This pattern of wage growth following an increase in the minimum wage is similar - although muted - when I look at "all workers" as opposed to "hourly workers" only. These results, which are presented in columns (e)-(h) of Table 2, imply that the ripple effect is more-pronounced on hourly workers. Thus, for much of the analysis that follows, I focus exclusively on hourly workers.

The question remains: are these wage gains associated with the ripple effect offset by falling employment? These estimates of the "ripple effect on employment" are presented in columns (a)-(d) of Table 3 and imply that there is no significant employment response.[30] Indeed, to the extent that there is a pattern, hours of work may increase slightly. These

Table 3: Employment and Earnings Ripple Effects
The Effect of the Minimum Wage on Hours Worked and Earnings
Hourly Workers Only

	Hours of Work				**Weekly Earnings**			
Wage Grouping	**T-1**	**T**	**T+1**	**T+2**	**T-1**	**T**	**T+1**	**T+2**
	(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**
$mw \leq w < 1.05 * mw$	0.04	0.36	0.21	-0.41	0.21	0.93**	0.80*	-0.46
	(0.25)	(0.35)	(0.34)	(0.40)	(0.26)	(0.39)	(0.42)	(0.40)
$1.05 * mw \leq w < 1.15 * mw$	-0.04	-0.16	0.12	-0.12	0.23	0.05	0.73*	0.19
	(0.18)	(0.22)	(0.27)	(0.29)	(0.18)	(0.28)	(0.42)	(0.32)
$1.15 * mw \leq w < 1.5 * mw$	-0.05	-0.09	0.18	0.34***	-0.01	0.08	0.34*	0.53***
	(0.07)	(0.14)	(0.18)	(0.11)	(0.09)	(0.15)	(0.20)	(0.14)
$1.5 * mw \leq w < 1.75 * mw$	-0.02	0.03	-0.15	0.21	-0.08	0.12	-0.05	0.46*
	(0.05)	(0.09)	(0.10)	(0.30)	(0.07)	(0.08)	(0.11)	(0.24)
$1.75 * mw \leq w < 2 * mw$	-0.08	-0.03	0.09	0.13	-0.03	0.05	0.30***	0.29
	(0.06)	(0.08)	(0.09)	(0.28)	(0.08)	(0.15)	(0.11)	(0.27)
$2 * mw \leq w < 2.5 * mw$	-0.03	0.00	-0.04	0.07	-0.06	-0.07	-0.09	0.33
	(0.05)	(0.05)	(0.06)	(0.15)	(0.06)	(0.07)	(0.12)	(0.26)
$2.5 * mw \leq w < 4 * mw$	0.01	0.07*	-0.04	0.02	-0.01	0.08	-0.03	0.32
	(0.03)	(0.04)	(0.07)	(0.14)	(0.05)	(0.07)	(0.10)	(0.26)
$4 * mw \leq w < 6 * mw$	0.03	0.16	0.02	0.17	0.02	0.13	0.01	-0.41***
	(0.04)	(0.11)	(0.21)	(0.15)	(0.06)	(0.16)	(0.22)	(0.16)

Notes: The ripple effect is estimated as the elasticity of weekly hours (earnings) following an increase in the minimum wage. Standard errors were clustered at the state level and sample weights were used in the estimation. Period T refers to the period just following the increase in the minimum wage; T-1 (T+1) is 1 year prior to (after) the increase; etc.

results are further supported by the estimates of the ripple effect of minimum wages on weekly earnings presented in columns (e)-(h) of Table 3. These estimates are generally

[30] There is also no evidence that employees faced elevated involuntary transition probabilities – see Table 6. Thus, these results, which only examine those still employed, do not mask other disemployment effects.

similar to the wage effects, although they are slightly larger in magnitude. Thus, the wage gains associated with the ripple effect do not appear to be offset with any particular pattern of employment reductions following the increase.[31]

While these estimates of the immediate wage effect are similar to the results in Neumark, Schweitzer, and Wascher (2004), they differ in terms of how far the ripple effect extends into the wage distribution and the lagged effects. Neumark, Schweitzer, and Wascher (2004) estimate a ripple effect that is extremely short lived, where workers actually "pay back" the immediate wage gains with subsequent relative wage losses in the year after the increase. For example, they find that workers paid 10%-20% above the minimum wage experience a 4% increase in their relative wages in the immediate period (i.e. period "T") after a 10% increase in the the minimum wage, but then experience a 4% decrease in their relative wages in the following year. This pattern of relative wage gains followed by relative wage losses is very different from what I find: a fairly persistent and positive ripple effect.

The short-lived ripple effect in Neumark, Schweitzer, and Wascher (2004) may, in fact, be due to a limitation in their data, the matched CPS.[32] Since they only observe an individual for two consecutive years, the base wage in their lagged effect analysis is actually the individual's wage after the minimum wage already increased. Since both of our analyses imply that individuals experience immediate relative wage growth (following an increase in the minimum wage) that is smaller than the percent increase in the minimum wage, the ratio of an individual's wage to the minimum wage decreases when the minimum increases. This means that the control group for the same individual (if one only has two years of data) effectively changes in their lagged analysis in a way that may effect how one analyzes future wage growth. If wage growth is a function of both the wage level and the ratio of the wage to the minimum wage, then using the wage-to-minimum wage ratio after the minimum increases (to group individuals) will understate the lagged ripple effect.

To address this issue, I re-estimate the ripple effect using two year increments from the SIPP to simulate the data restrictions in the matched CPS. As shown in columns (c) and (d) of Table 4, when I condition my wage groupings (and wage growth) on wages in the

[31] Table A4 in the appendix includes the results for ripple effects estimates on hours and earnings on all workers, not simply workers being paid on an hourly basis.

[32] The matched CPS is also known as the merged outgoing rotation group (MORG) of the CPS.

previous year, I also find this cycling effect: where positive wage gains are followed by wage losses that, at times, completely offset the positive benefit in the first period. Notably, this pattern of results does not happen (using the same data) when wage intervals and wage changes are conditioned on the first period wage. This is shown in columns (a) and (b).[33]

Table 4: Alternate Estimates of the Ripple Effect
Comparing Estimates with Shorter and Longer Panels
Hourly Employees by Wage Grouping

	Full Panel Estimates in the SIPP		**2-Period Panel Estimates from the SIPP**	
Wage Grouping	**T**	**T+1**	**T**	**T+1**
	(a)	**(b)**	**(c)**	**(d)**
$mw \leq w < 1.05 * mw$	0.55***	0.60***	0.76***	-0.05
	(0.09)	(0.21)	(0.05)	(0.05)
$1.05 * mw \leq w < 1.15 * mw$	0.12	0.45**	0.48***	-0.07
	(0.13)	(0.20)	(0.11)	(0.06)
$1.15 * mw \leq w < 1.5 * mw$	0.18***	0.17***	0.09***	-0.11**
	(0.03)	(0.06)	(0.02)	(0.05)
$1.5 * mw \leq w < 1.75 * mw$	0.09**	0.16**	0.01	-0.05
	(0.04)	(0.07)	(0.04)	(0.04)
$1.75 * mw \leq w < 2 * mw$	0.07	0.20**	-0.02	-0.12**
	(0.10)	(0.07)	(0.04)	(0.06)
$2 * mw \leq w < 2.5 * mw$	-0.04	-0.03	0.01	-0.04
	(0.05)	(0.08)	(0.02)	(0.05)
$2.5 * mw \leq w < 4 * mw$	0.00	0.06	-0.01	-0.05**
	(0.04)	(0.08)	(0.02)	(0.02)
$4 * mw \leq w < 6 * mw$	0.00	-0.10	0.05*	-0.09**
	(0.08)	(0.09)	(0.03)	(0.04)

Notes: The ripple effect is the estimated elasticity of wages following an increase in the minimum wage. Standard errors were clustered at the state level and sample weights were used in the estimation. Period T refers to the period just following the increase in the minimum wage; T+1 is 1 year after the increase.

Thus, this finding that employers "take back" the benefits of the ripple effect one year later appears to be due to a limitation in the data used by Neumark, Schweitzer, and Wascher (2004) – as opposed to an actual loss of wages in subsequent years.[34] Interestingly, when

[33]The results in Table 4 only focus on the effects in periods T and T+1 because I wanted to mimic the analysis in Neumark, Schweitzer, and Wascher (2004) as close as possible. However, including the period before the minimum increased (T-1) and the period two years after the minimum increased (T+2) does not materially change the results.

[34]While the SIPP is better at getting around this wage-anchoring problem in the MORG, the SIPP also suffers from the same problem since it only follows individuals for four years and I have included

I mimic the set-up in Neumark, Schweitzer, and Wascher (2004), I also find ripple effect estimates that extend further into the wage distribution.

Taken together, I document a more persistent and positive ripple effect in wages that is not subject to subsequent employment reductions. While this ripple effect predominantly affects hourly workers being paid less than twice the minimum wage, this does not imply that the ripple effect is not broadly felt. According to the SIPP, approximately 60% of all employed individuals are hourly workers and, of hourly workers, more than 50% are paid less than twice the minimum wage. Thus, according to the SIPP, the ripple effect affects the wages of approximately 30% of the labor force. This combination of persistent wage gains and the prevalence of this effect on low-wage workers highlights the importance of understanding why the ripple effect is taking place and who benefits.

6 Distinguishing Supply and Demand Substitution

The second empirical goal of this paper is to better understand the causes of the ripple effect: labor supply or labor demand substitution. I do this in two ways. First, supply and demand substitution imply that the ripple effect in wages should "move" through the wage distribution differently, where supply substitution is consistent with a larger and more prominent ripple effect among individuals employed in hedonically less desirable jobs, and demand substitution is consistent with a larger and more prominent ripple effect among higher skilled individuals. Given these implications, I re-estimate the ripple effect with interaction terms that capture individual skill premiums and occupation-level hedonic compensation. The coefficients on these interacted terms (as well as their effect on the non-interacted ripple effect coefficients) will help assess the support for these two potential causes.

Second, supply and demand substitution also imply different patterns of voluntary and involuntary employment adjustments following changes in the minimum wage. Supply substitution is consistent with voluntary labor market transitions away from hedonically undesirable jobs and movements towards hedonically more desirable (but lower paying) jobs.

changes in the minimum wage that happened prior to 2004 in the empirical analysis. Thus, I too am likely underestimating the persistent effects of the ripple effect. I find evidence supportive of this assertion and it is available upon request.

Demand substitution, on the other hand, is associated involuntary transitions of low skilled individuals and voluntary transitions of higher skilled individuals – increasing the overall skill level within an occupation. Thus, I first examine the individual-level patterns of voluntary and involuntary transitions (in the SIPP) following increases in the minimum wage. I then test the extent to which these individual reemployment patterns are evident in aggregate state-level occupational employment data in the CPS. The empirical specifications of these tests are described below.

6.1 The Ripple Effect in Wages across Skills & Hedonics

To distinguish between labor supply and labor demand substitution in the wage changes following changes in the minimum wage, I separately interact the change in the minimum wage with an individual's first period skill premium (E_{i1}) and the hedonic wage premium ($H_{k,t-1}$) of their lagged occupation.[35] This leads to the following expression:

$$\begin{aligned}
\Delta \ln W^{p}_{ist} =& \alpha + \alpha_s + \alpha_t + \sum_{z=-2}^{1} \sum_{j=1} \beta^{z}_{j} \Delta \ln MW_{s,t+z} R(W^1_{is}, MW^1_s)^j \\
&+ \sum_{z=-2}^{1} \sum_{j=1} \beta^{z}_{jE} \Delta \ln MW_{s,t+z} R(W^1_{is}, MW^1_s)^j * E_{i1} \\
&+ \sum_{z=-2}^{1} \sum_{j=1} \beta^{z}_{jH} \Delta \ln MW_{s,t+z} R(W^1_{is}, MW^1_s)^j * H_{k,t-1} \\
&+ \sum_{j=1} \phi_j \ln W^1_{is} * R(W^1_{is}, MW^1_s)^j + \sum_{j=1} \psi_j (p-1) R(W^1_{is}, MW^1_s)^j \\
&+ \sum_{j=1} \pi_j E_{i1} * R(W^1_{is}, MW^1_s)^j + \sum_{j=1} \xi_j H_{k,t-1} * R(W^1_{is}, MW^1_s)^j \\
&+ \sum_{j=1} \gamma_j R(W^1_{is}, MW^1_s)^j + \delta X_{ist} + \epsilon_{ist}
\end{aligned} \tag{7}$$

where all variables are the same as in equation (6). Like equation (6), the specification is also estimated using sample weights, the standard errors are clustered at the state level, and I exclude the same outlier observations. One difference, however, is that I condense the

[35] These skill and hedonic metrics were described in Section 4.2 and 4.3.

number of non-linear wage intervals associated with $R(W_{is}^1, MW_s^1)^j$ from 8 to 4;[36] and the β_j^z coefficients in equation (7) are estimated both (i) for each of the four periods (i.e. T-1, T, T+1, and T+2) and (ii) over a single aggregated period which uses the average change in the minimum wage over T-1, T, T+1, and T+2. Both of these adjustments (fewer wage intervals and fewer periods) are necessary because of sample size concerns.

Under this specification, the "movement" of the ripple effect across individuals with different skill premiums and across individuals coming from occupations with different compensating wage differentials is captured by the β_{jE}^z and β_{jH}^z coefficients. These coefficients capture the additional wage changes associated with an individual's skill and their occupation's hedonic compensation when the minimum increases. Positive and significant estimates of the β_{jE}^z coefficients mean that higher skilled workers receive larger wage increases following an increase in the minimum wage – implying that labor demand substitution explains (at least some portion of) the ripple effect. On the other hand, positive and significant estimates of the β_{jH}^z coefficients mean that workers at hedonically less desirable jobs(i.e. those with large compensating wage differentials) experience larger wage increases when the minimum wage increases – implying that labor supply substitution explains (at least some portion of) the ripple effect.

Interestingly, because I index individual skill premiums (E_{i1}) and hedonic wage premiums ($H_{k,t-1}$) relative to their minimum value, the β_j^z coefficients (i.e. the non-interacted ripple effect coefficients) then capture the extent to which the ripple effect cannot be explained by either labor demand or labor supply substitution. Thus, the residual β_j^z coefficients may capture the "equity effect" or efficiency wage effect described in Grossman (1983).[37]

6.1.1 Estimates of the Ripple Effect across Skills & Hedonics

The ripple effect estimates with hedonic and skill interaction terms are presented in Table 5. They demonstrate that the wage gains associated with the ripple effect are directly

[36] The condensing simply merges together $R(W_{is}^1, MW_s^1)^1$ and $R(W_{is}^1, MW_s^1)^2$ into one group, $R(W_{is}^1, MW_s^1)^3$ and $R(W_{is}^1, MW_s^1)^4$ into one group, $R(W_{is}^1, MW_s^1)^5$ and $R(W_{is}^1, MW_s^1)^6$ into one group, and $R(W_{is}^1, MW_s^1)^7$ and $R(W_{is}^1, MW_s^1)^8$ into one group.

[37] This idea of an efficiency wage effect has also been suggested by Katz and Krueger (1992) and Card and Krueger (1995).

related to the hedonic compensation at one's occupation and thus, they suggest that the ripple effect is largely caused by labor supply substitution. Not only does the inclusion of these interaction terms make the non-interacted ripple effect coefficients go to zero, but the coefficients on the hedonic compensation interacted term (in columns (b), (c), and (d)) are quite large and both economically and statistically significant. At the same time, the coefficients on the skill premium interaction term are generally not economically nor

Table 5: Ripple Effect Estimates Across Skill and Hedonic Compensation Indices
Hourly Workers by Wage Grouping - Periods Combined

	Wage Group	**No Interactions**	**Skill and Hedonic Interactions with Δ Minimum Wage**		
			Specification 1:		**Specification 2:**
		(a)	**(b)**	**(c)**	**(d)**
Changes in the Minimum Wage	$w < 1.15 * mw$	1.12***	0.11	-0.01	0.09
		(0.18)	(0.27)	(0.60)	(0.60)
	$1.15 * mw \leq w < 1.75 * mw$	0.22**	-0.23	-0.26	-0.51**
		(0.10)	(0.19)	(0.30)	(0.24)
	$1.75 * mw \leq w < 2.5 * mw$	-0.02	-0.55	-0.76*	-0.96**
		(0.15)	(0.35)	(0.46)	(0.39)
	$2.5 * mw \leq w < 6 * mw$	-0.14	-0.87***	-1.75***	-1.88***
		(0.13)	(0.26)	(0.40)	(0.38)
Skill Premium X Changes in the Minimum Wage	$w < 1.15 * mw$			0.38	0.17
				(3.48)	(3.36)
	$1.15 * mw \leq w < 1.75 * mw$			0.18	0.59
				(1.08)	(1.16)
	$1.75 * mw \leq w < 2.5 * mw$			1.70	1.24
				(1.31)	(1.36)
	$2.5 * mw \leq w < 6 * mw$			4.52***	3.83***
				(1.20)	(1.15)
Hedonic Compensation Index X Changes in the Minimum Wage	$w < 1.15 * mw$		15.16***	14.57***	13.63***
			(4.49)	(4.59)	(4.56)
	$1.15 * mw \leq w < 1.75 * mw$		3.58**	3.12**	4.75***
			(1.41)	(1.40)	(1.46)
	$1.75 * mw \leq w < 2.5 * mw$		4.13*	3.20	5.50**
			(2.27)	(2.57)	(2.17)
	$2.5 * mw \leq w < 6 * mw$		2.54**	2.45**	3.40***
			(0.94)	(0.89)	(0.86)

Notes: The ripple effect is estimated as the elasticity of wages following an increase in the minimum wage. The Skill Index is simply the estimated wage premium associated with an individual's education and labor market experience; while the Hedonic Compensation Index is the estimated hedonic wage premium associated with the hedonic characteristics of an individual's occupation in the previous period. Both indices are indexed relative to the minimum value, which takes the value zero. Standard errors are clustered at the state level and sample weights are used in the estimation. Moreover, periods T-1, T, T+1, and T+2 were combined by taking the average change in the minimum wage over those periods. Lastly, Specification 2 (S2) differs from Specification 1 in that in S2 the π and ξ coefficients from equation (7) were forced to equal the π and ξ coefficients of (7) estimated on the sub-sample of individuals for whom the minimum wage did not change in any of the T-1 to T+2 periods. In S2, the standard errors are the standard errors from 1000 bootstraps.

statistically significant – except for individuals being paid more than two-and-a-half times the minimum wage. Thus, wage growth associated with the ripple effect differentially occurs at occupations with increasing hedonic compensation.

The magnitudes of these coefficients is worth clarifying. First, the coefficients in Table 5 are from the iteration of equation (7) that uses the average change in the minimum wage over all four periods (T-1, T, T+1, and T+2) as its measure of the change in the minimum wage.[38] Thus, the coefficients in Table 5 capture the total wage gains over the four year period. Second, these estimates are from interaction terms, so to make sense of the coefficients, one must assume a level of hedonic compensation. For example, the coefficient 15.16 implies that individuals making just under 15% above the minimum wage but employed at an occupation with a 10% hedonic premium (over the minimum hedonic compensation) will experience a total wage premium of 15% if the minimum wage increases by 10%. Thus, if the wage premium was evenly spread across all 4 years, this implies that the individual experienced relative wage growth of 3.7% in each of the four year.

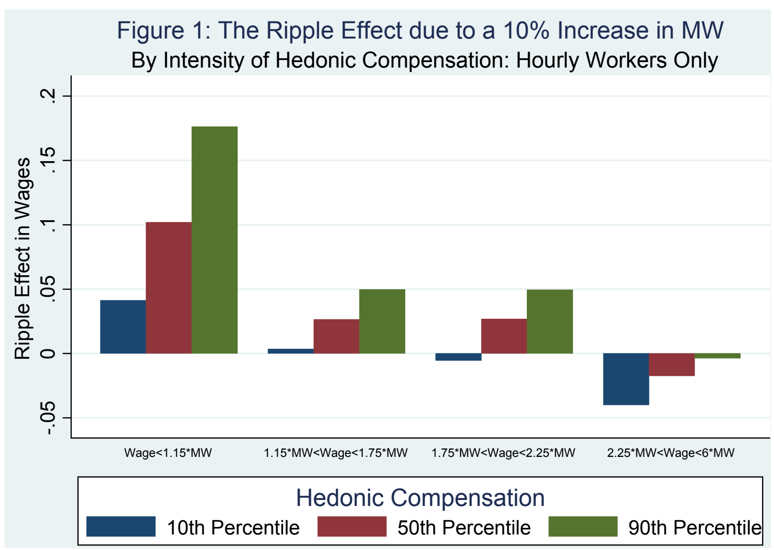


Figure 1 depicts this aggregate premium for each of the wage intervals for individuals employed at occupations in the 10th percentile, median, and 90th percentile of the actual distribution of hedonic compensation within each wage interval.[39] As depicted in Figure

[38] Table A5 in the appendix includes the results where each period is estimated separately

[39] The figure is based off of the coefficients in column (c) of Table 5, where point estimates use the average individual's skill index within the interval.

1, there is a very strong relationship between the hedonic compensation of an individual's occupation and the subsequent wage growth that the individual experiences following an increase in the minimum wage.

At the same time, there is almost no relationship between an individual's skill premium and their realized ripple effect. While the coefficients in Table 5 are positive (as one would expect with labor demand substitution), they are generally not statistically significant and the magnitude of the estimated effects are generally quite small. This is particularly true for those individuals most affected by the ripple effect – individuals earning less than twice the minimum wage. That said, there does seem to be somewhat of a skill-based wage adjustment for the highest-wage individuals – those earning more than 150% above the minimum. This pattern is depicted in Figure 2, which like Figure 1, shows the average ripple effect for individual's in the 10th percentile, median, and 90th percentile of the actual skill distribution within each wage interval.

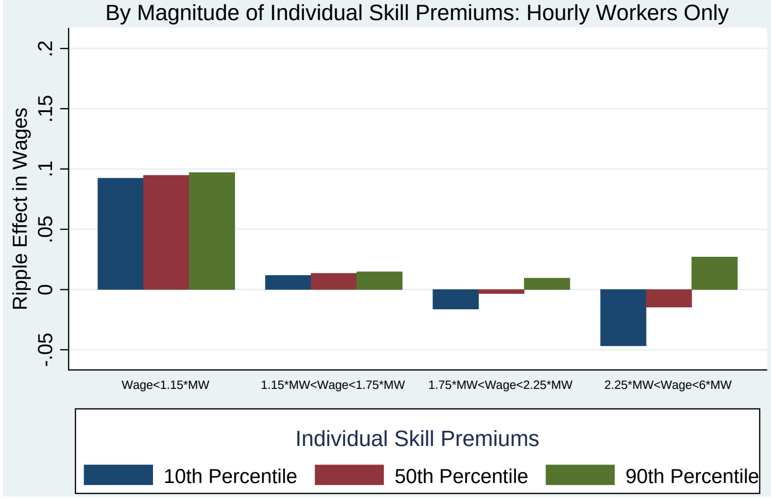


Figure 2: The Ripple Effect due to a 10% Increase in MW
By Magnitude of Individual Skill Premiums: Hourly Workers Only

These results demonstrate that the movement of the ripple effect is best characterized by increases in wages across hedonically distinct occupations as opposed to increases in wages across different skill levels. Additionally, this combination of wage growth along hedonic and skill dimensions seems to explain the entirety of the ripple effect – since the non-interacted β_j-coefficients go to zero or even become negative when the interaction terms are included. Thus, this pattern of wage growth following increases in the minimum wage suggests that labor supply substitution (away from hedonically undesirable jobs) is the predominant cause of the ripple effect – especially on lower wage workers where the ripple is most prominent. At the same time, there is almost no role for labor demand substitution (except for very high earners); and Grossman's (1983) "equity effect" (or efficiency wage argument) has no support in the data.

6.2 The Individual Employment Response to the Ripple Effect

A second test of the underlying causes of the ripple effect is to examine the employment response to changes in the minimum wage. In terms of individual transitions, labor supply substitution is associated with voluntary transitions away from hedonically less desirable jobs and towards hedonically more-desirable jobs; while labor demand substitution is associated with involuntary transitions (i.e. layoffs) of low skilled workers and voluntary transitions of higher skilled workers. Thus, labor supply substitution implies a particular pattern of labor movement *across* occupations while labor demand substitution implies a particular pattern of mobility *within* occupations.

These distinct employment responses to changes in the minimum wage should be evident (to the extent they exist) in panel data on individuals. Thus, I also use the SIPP to examine *who* makes voluntary and involuntary transitions and *what* are the outcomes of those that do make transitions.

6.2.1 Who Transitions?

The probability that an individual makes a voluntary labor market transition over the past year is estimated using the following probit specification:

$$\begin{aligned} Pr(VolTrans_t = 1) = &\Phi(\alpha + \alpha_s + \alpha_t + \sum_{z=-2}^{1} \sum_{j=1} \beta_j^z \Delta \ln MW_{s,t+z} * R(W_{is}^1, MW_s^1)^j \\ &+ \sum_{j=1} \phi_j \ln W_{is}^1 * R(W_{is}^1, MW_s^1)^j \\ &+ \sum_{j=1} \gamma_j R(W_{ist}^1, MW_{st}^1)^j + \delta X_{is,t-1}) \end{aligned} \tag{8}$$

where all of the explanatory variables are identical to those included in equation (6), except that I use lagged values of the individual controls ($X_{is,t-1}$) such as firm-level tenure and union status. Like equation (7), the implementation of this specification also focuses on 4 non-linear wage intervals associated with the $R(W_{is}^1, MW_s^1)^j$ indicator variable and changes in the minimum wage are averaged across multiple periods. An identical specification is also estimated to examine the pattern of involuntary transitions, i.e. layoffs and other dismissals.[40]

To evaluate *who* makes voluntary transitions (or involuntary transitions) when the minimum wage increases, I estimate equation (8) separately for high- and low-skill individuals and separately for those who were employed in high- and low-hedonic compensating occupations – where "high" values are above median and "low" values are below median. I opt for this discrete cutting of the data because even though labor supply substitution implies that there should be elevated voluntary transition probabilities from individuals at hedonically undesirable jobs, a monotonic relationship between hedonic compensation and elevated voluntary transition probabilities is unlikely to occur due to individual heterogeneity. The same argument applies to individual skills and demand substitution.

6.2.2 Outcomes of Individual Transitions

Labor supply and labor demand substitution also imply different outcomes for those that do make these voluntary transitions. In particular, workers making a voluntary transition because of labor supply substitution should move to jobs with smaller hedonic wage premiums and lower wages, while workers making a voluntary transition because of labor demand substitution should experience no systematic change in their hedonic compensation, but rising wages.

To test whether individuals do indeed move to occupations with less hedonic compensation, I estimate two alternate versions of equation (7). In the first version, I simply change the dependent variable to the year-over-year change in hedonic compensation (i.e. $H_{ist} - H_{is,t-1}$). In the second version, I keep the same dependent variable but exclude the skill and

[40]I distinguish between voluntary and involuntary labor market transitions using the "reason stopped working for an employer" variable in the SIPP; where "quits" are voluntary transitions and "layoffs," and "discharges" are involuntary transitions.

hedonic interaction terms and add a new interaction term: the additional ripple effects on those individuals making voluntary transitions, (i.e. $\sum_{z=-2}^{1}\sum_{j=1}\beta_{jV}^{z}\Delta\ln MW_{s,t+z}R(W_{ist}^{1}, MW_{st}^{1})^{j} * VolTrans$).

6.2.3 Results of Individual Transitions in SIPP

The voluntary and involuntary transition probit results are presented in Table 6 separately for all hourly workers, high- and low-skill hourly workers, and hourly workers coming from high- and low-hedonically compensated occupations. The coefficients highlight elevated

Table 6: Marginal Effects of ΔMW on Voluntary and Involuntary Transitions
Hourly Workers for Skill and Hedonic Sub-samples

Wage Group	All Workers	Low Skill	High Skill	Low Hedonics	High Hedonics
	Voluntary Transitions				
	(a)	(b)	(c)	(d)	(e)
$w < 1.15 * mw$	0.25 (0.20)	0.71** (0.29)	-0.27 (0.29)	0.44 (0.27)	0.01 (0.29)
$1.15 * mw \leq w < 1.75 * mw$	0.26*** (0.09)	0.28* (0.17)	0.24* (0.13)	0.22 (0.13)	0.26* (0.15)
$1.75 * mw \leq w < 2.5 * mw$	0.31*** (0.08)	0.48*** (0.16)	0.14 (0.10)	0.15 (0.16)	0.46*** (0.15)
$4 * mw \leq w < 6 * mw$	0.14 (0.09)	0.20 (0.15)	0.10 (0.12)	-0.13 (0.11)	0.38** (0.15)
	Involuntary Transitions				
$w < 1.15 * mw$	-0.20 (0.13)	-0.14 (0.17)	-0.25 (0.21)	-0.38*** (0.13)	-0.07 (0.17)
$1.15 * mw \leq w < 1.75 * mw$	0.02 (0.07)	0.02 (0.08)	0.01 (0.08)	0.01 (0.09)	0.04 (0.10)
$1.75 * mw \leq w < 2.5 * mw$	0.05 (0.05)	0.05 (0.08)	0.04 (0.08)	-0.05 (0.07)	0.15 (0.10)
$4 * mw \leq w < 6 * mw$	0.04 (0.06)	0.03 (0.08)	0.03 (0.09)	-0.05 (0.05)	0.14 (0.12)

Notes: Voluntary job changes are labor market transitions due to a worker "quit" only. Involuntary job changes are labor market transitions due to a worker experiencing a "layoff" or being "fired." "Low Skill" workers are individuals with a combinations of education and experience that is compensated in bottom 50% of all people in their wage grouping. "Low Hedonics" observations are individuals employed in occupations (in the lagged period) that had compensating differentials in bottom 50% of occupations in their wage grouping. Standard errors were clustered at the state level and sample weights were used in the estimation. All coefficients are estimated using the average change in the minimum wage over the previous year, the current year, and the following year.

voluntary transition probabilities among low-skilled individuals coming from hedonically undesirable occupations. For example, individuals coming from occupations with above-median hedonic compensation face voluntary transition probabilities that are 2.6 to 4.6 percentage points higher if the minimum wage increases by 10%. Since the overall voluntary transition probability are 11%, 6%, and 4% for individuals in the second, third, and fourth wage intervals, respectively, these percentage point increases are quite large in magnitude.[41] This pattern of voluntary labor market transitions following an increase in the minimum wage is precisely what one would expect if labor supply substitution was taking place.

At the same time, there is no evidence of labor demand substitution in the transition probabilities. In particular, there is no pattern of elevated voluntary transition probabilities among higher skilled individuals and there is no pattern of elevated involuntary transition probabilities among low skilled workers (or any individuals for that matter).

The question remains: what happens to those individuals that do make voluntary transitions following an increase in the minimum wage. Do these individuals move to hedonically more-desirable jobs as supply substitution would imply? Also, what happens to their wages? Do they increase as demand substitution would imply or decrease as supply substitution imply? These results are presented in Table 7, with the hedonic adjustments in columns (a)-(c) and the wage adjustments in columns (d)-(e).

The results in Table 7 show that individuals who do make voluntary transitions following an increase in the minimum wage tend to move to occupations with less hedonic compensation (i.e. hedonically more-desirable jobs). For example, the coefficients imply that a 10% increase in the minimum wage leads individuals employed at an occupation with hedonic compensation of 10% above the most-desirable job to move to a job with about 2.8% less hedonic compensation. At the same time, this pattern of reemployment of individuals moving to hedonically more desirable jobs is associated with lower wages – at least for those making more than 75% above the minimum wage. Indeed, the decline in hedonic compensation and the wage loss figures in Table 7 are surprisingly consistent for higher wage earners.[42]

[41] Like the results in Table 5, the results in Table 6 do not break out separate effects for periods T-1, T, T+1, and T+2. The reason for this is that I combine changes in the minimum wages over T-1, T, and T+1 as the average change over that period to improve the predictive power of my estimates. The results are qualitatively similar if I include distinct values for each period.

[42] For example, the wage losses associated with those that do make voluntary labor market transitions following a 10% increase in the minimum wage is -3.9% and -6% for individuals in the two highest wage

Table 7: Individual Hedonic and Wage Adjustments
Following Voluntary Transitions and Minimum Wage Increases
Hourly Workers Only

	Hedonic Adjustments			**Wage Adjustments**	
		Skill Index X	**Hedonic Index X**		**Vol Trans X**
	Change in MW	**Change in MW**	**Change in MW**	**Change in MW**	**Change in MW**
	(a)	**(b)**	**(c)**	**(d)**	**(e)**
$w < 1.15 * mw$	-0.07	-1.21	0.16	0.63**	0.39
	(0.10)	(1.39)	(1.55)	(0.15)	(0.28)
$1.15 * mw \leq w < 1.75 * mw$	-0.05	-0.48	-2.79**	0.04	-0.01
	(0.06)	(0.35)	(1.21)	(0.08)	(0.15)
$1.75 * mw \leq w < 2.5 * mw$	-0.25**	-1.41**	-2.83**	-0.08	-0.39**
	(0.11)	(0.66)	(1.35)	(0.06)	(0.15)
$2.5 * mw \leq w < 6 * mw$	-0.11	-2.64*	-2.86**	-0.12	-0.60**
	(0.08)	(1.51)	(1.30)	(0.04)	(0.27)

Notes: Hedonic adjustments are the change in hedonic compensation when an individual changes jobs. A positive adjustment implies an individual moved to a job that now requires additional wage offsets and vice versa. Wage adjustments are the change in wages when an individual changes jobs. Voluntary transitions are all "quits" in the SIPP. The Skill Index and Hedonic Index are simply the estimated compensation associated with an individual's education and experience (for the skill index) and the hedonic characteristics of their lagged occupation. Both indices are indexed relative to their minimum. Standard errors were clustered at the state level and sample weights were used in the estimation, All coefficients are estimated using the average change in the minimum wage over the previous year, the current year, and the following year.

This analysis of the voluntary and involuntary transitions of individual workers in the SIPP is also largely consistent with the notion that labor supply substitution is the primary cause of the ripple effect. The results demonstrate a clear pattern of occupational transitions – whereby increases in the minimum wage lead to elevated voluntary labor market transitions away from hedonically undesirable occupations towards hedonically more desirable jobs that pay lower wages. At the same time, there is no evidence of elevated voluntary transition probabilities among higher skilled workers, nor any evidence of elevated involuntary transition probabilities among lower skilled workers. Thus, the evidence on *who* transitions following an increase in the minimum wage and *what* happens to these individuals is supportive of labor supply substitution.

6.3 Aggregate Occupation-Level Employment Adjustments

Lastly, I test whether these individual-level employment adjustments implied by labor supply and labor demand substitution are evident in state-level occupational employment data

intervals. On the other hand, the average person in these intervals is coming from occupations with a hedonic wage premium of 0.11 and 0.20 (respectively). These hedonic adjustments alone should be associated with wage losses equal to 0.11*-2.83*0.1=-3.1% for individuals making between 75% and 150% above the minimum wage and 0.2*-2.86*0.1=-5.7% for the highest earners.

from the CPS. The empirical approach to this test is similar to the ripple effect but the unit of measure is now an occupation:

$$\begin{aligned}\Delta \ln L_{kst} =& R(W_{ks}^{2004}, MW_s^{2004})^j * \Big[\alpha + \alpha_s + \alpha_t + \alpha_k \\ &+ \sum_{z=-2}^{1} \beta_j^z \Delta \ln MW_{s,t+z} + \sum_{z=-2}^{1} \beta_{jE}^z \Delta \ln MW_{s,t+z} * E_{k,2004} \\ &+ \sum_{z=-2}^{1} \beta_{jH}^z \Delta \ln MW_{s,t+z} * H_k + \beta_1 \ln L_{ks}^{2004} \\ &+ \beta_2 \ln W_{ks}^{2004} + \beta_3 (t-2004) + \beta_4 E_{ks,2004} \\ &+ \beta_5 H_{ks,2004} + \delta X_{kst} + \epsilon_{kst}\Big]\end{aligned} \tag{9}$$

where $\Delta \ln L_{kst}$ is the change in the log of total employment (measured both in total hours and total employees) from 2004 to year t; and each occupations is sorted into a particular wage interval, $R(W_{ks}^{2004}, MW_s^{2004})^j$, according to their average wage-to-minimum-wage across all states in 2004. Like equation (7), equation (9) is estimated both or each z-period separately and using the average change in the minimum wage over all periods. Unlike equation (7), all variables are interacted with the non-linear wage interval indicators, which simply means that the specification is estimated separately for each wage interval.[43] In terms of the other variables in the specification, the occupation-level hedonic compensation comes from the SIPP estimate, the average skill premium within an occupation in a state is the average individual skill premium (from estimates of a specification similar to (5) on the CPS sample), and the other occupation-level demographic controls (X_{kst}) from the CPS.[44]

There are two additional differences in the estimation of equation (9) – compared to equation (7). First, since the wage intervals are based on occupation-level averages of the wage-to-minimum wage, the cutoffs associated with the wage intervals (i.e. the $R(W_{kst}^1, MW_{st}^1)^j$ variables) are different because the average wages within an occupation tend to be well above the minimum wage. Thus, in (9), I categorize occupations into 4 wage intervals: occupations where the average wage-to-minimum-wage (i.e. $\frac{1}{N}\sum_{i=1}^{N}\frac{W_{iks}^{2004}}{MW_s^{2004}}$) is less than 2,

[43] This approach is appropriate due to the aggregation of occupations that takes place.

[44] The specific controls include percent female, the percent black, the share of workers that were students, and the average labor market experience of employees.

between 2 and 3, between 3 and 4, and between 4 and 6.

Second, in constructing this state-level occupational employment panel, the number of observations for a single 3-digit occupation within a state can vary quite significantly from year-to-year. Much of this is sampling variation as opposed to true changes in employment levels. Thus, to get around this issue, I group occupations (within each of the four wage intervals) into 20 composite occupations based upon their average hedonic compensation – where e.g. all occupations in the lowest 5% of hedonic compensation are combined into a single "occupation" with a single level of employment, a single average hedonic compensation, a single average percent female, etc. This adjustment is necessary to combat the small sample sizes within particular occupations in particular states.

The same approach is taken in the skill-based analysis to assess whether labor demand substitution is occurring. In this application, occupations (within wage intervals) are grouped into 20 "occupations" based upon their average skill premium in 2004. Then, equation (9) is estimated without the interaction terms to see how employment (both hours of work and total employees) changes when the minimum wage increases. This estimation is done separately for all workers, all high-skill workers, and all low-skill workers. The results allow me to answer the question: does the share of high-skill workers increase (relative to all workers or all low-skill workers) when the minimum wage increases.

Despite these adjustments to the data, there are still some "occupations" that experience enormous year-over-year employment fluctuations. To address this, I exclude observations if the average year-over-year change in the log employment levels exceeded $\pm$ 0.5 log points. These outlier observations are unlikely to reflect true employment adjustments, but rather, sample variation. At the very least, employment adjustments of this magnitude are unlikely to result from changes in the minimum wage.

6.3.1 Results: Employment Adjustments in the CPS

The state-level occupational employment response to the minimum wage (when occupations are grouped according to their hedonic compensation) is presented in Table 8. Columns (a) and (b) depict the total employment response to increases in the minimum wage, while columns (c) and (d) depict how this response differs across occupations with different average hedonic compensation and different average skill premiums. In terms of the total employment response in columns (a) and (b), the coefficients are negative but generally not statistically different than zero. Moreover, the magnitudes of the coefficients are quite

Table 8: The Ripple Effect of Minimum Wages on Employment Levels Within Hedonically Combined Occupations in the CPS 2004 – 2007

		Specification 1: No Interactions		Specification 2: Skill and Hedonic Interactions	
		Total Hours	Total Employees	Total Hours	Total Employees
		(a)	(b)	(c)	(d)
Changes in the Minimum Wage	$w < 2*mw$	-0.21	-0.40	-0.19	-0.38
		(0.45)	(0.53)	(0.44)	(0.51)
	$2*mw \leq w < 3*mw$	-0.39	-0.43*	-0.32	-0.35
		(0.26)	(0.25)	(0.28)	(0.29)
	$3*mw \leq w < 4*mw$	-0.24	-0.22	-0.22	-0.20
		(0.46)	(0.47)	(0.46)	(0.47)
	$4*mw \leq w < 6*mw$	-0.08	-0.11	-0.12	-0.14
		(0.46)	(0.44)	(0.46)	(0.44)
Skill Index X Changes in the Minimum Wage	$w < 2*mw$			-0.07	-0.31
				(0.31)	(0.34)
	$2*mw \leq w < 3*mw$			0.66*	0.76**
				(0.36)	(0.36)
	$3*mw \leq w < 4*mw$			0.12	0.14
				(0.19)	(0.19)
	$4*mw \leq w < 6*mw$			-0.38	-0.37
				(0.26)	(0.26)
Hedonic Compensation Index X Changes in the Minimum Wage	$w < 2*mw$			-12.56**	-22.48***
				(5.87)	(6.82)
	$2*mw \leq w < 3*mw$			-14.22***	-15.96***
				(3.58)	(3.63)
	$3*mw \leq w < 4*mw$			-6.94**	-7.75***
				(2.86)	(2.81)
	$4*mw \leq w < 6*mw$			4.86	2.36
				(5.18)	(4.98)

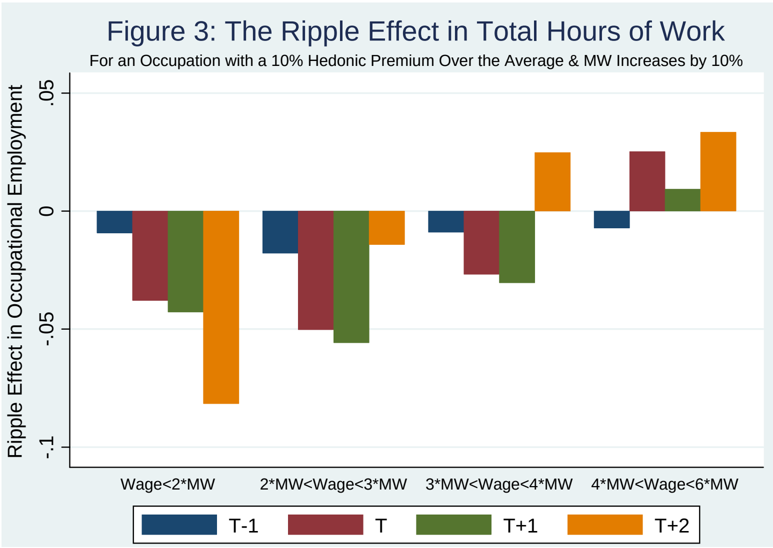
Notes: The Skill Index is simply the average education level in an occupation. The Hedonic Compensation Index is the hedonic compensation associated with estimates of equation (5) from the SIPP sample. These same values are applied to the occupations in the CPS data. Both indices are indexed relative to their mean value within the wage interval. The wage groupings differ in the CPS sample because these are average wages within an occupation and the sample sizes were too small using the groupings from the SIPP sample as in Table 4 and 5. Standard errors were clustered at the state and occupations were weighted by the number of observations associated with the total. All coefficients are estimated using the average change in the minimum wage over T-1, T, T+1, and T+2.

small, especially when one considers that these estimates capture the total 4-year response. Even the largest coefficient across both measures and all wage intervals, -0.43, implies that a 10% increase in the minimum wage leads to an average annual employment decline of about 1%. Thus, the estimates imply no significant overall employment reductions.

While there is no net change in employment, there is a very clear pattern of workers resorting themselves across occupations – whereby employment declines at hedonically undesirable jobs (i.e. those with high hedonic compensation) and increases at hedonically more-desirable occupations. This is evident in the coefficients on the hedonic interaction terms in columns (c) and (d). In this specification, an occupation's hedonic compensation is indexed relative to the average hedonic compensation across occupations in the wage interval. Thus, the negative coefficients imply that occupations with above average hedonic wage premiums experience decreasing employment levels while those with below average hedonic compensation experienced increasing employment levels. This re-sorting of workers across occupations is precisely what would be predicted by labor supply substitution; and it is consistent with the reemployment patterns of individuals in the SIPP.

The magnitude of this re-sorting is quite large, but not unreasonably large considering that these estimates capture the total effect (like Table 5) over the periods T-1, T, T+1, and T+2. Additionally, the coefficient estimates must be scaled by the degree of hedonic compensation. For example, the -12.56 coefficient on occupations paying less than twice the minimum wage implies that a hypothetical occupation with a 10% hedonic premium (above the average in the wage interval) will experience relative employment declines of 3% that persists for each of the 4 years (assuming the minimum wage increases by 10%). Interestingly, the coefficient estimates associated with the employment response at the extensive margin (see column (d)) are much larger than the intensive margin coefficients in column (c). This pattern of results may imply that the individuals that remain behind in these hedonically undesirable occupations respond to the higher wages by working more hours.

Of course, the employment decline at these hedonically undesirable occupations is unlikely to be evenly distributed across the four years. This is evidenced in the year-by-year estimates, which are presented in Table A6 and Table A7 in the Appendix. These year-by-year estimates of the hours response are also depicted in Figure 3, which depicts the employment declines at a hypothetical occupation with a 10% (above average) hedonic premium when the minimum wage increases by 10%. As before, these estimates imply that the opposite pattern (i.e. employment growth of an identical magnitude) at occupations with a hedonic premium that is 10% less than average. Indeed, this pattern of reemployment is not merely a phenomena at low wage levels, but it is also evident in occupations where individuals are paid up to four times the minimum wage. These findings are consistent with the individual reemployment patterns in the SIPP and offer additional support for the idea that labor supply substitution away from hedonically undesirable occupations is an important cause of the ripple effect of minimum wages.



Lastly, I examine the employment response to the minimum wage in occupations that have been grouped by the average skill premium of their employees to test whether the workforce within an occupation becomes more skilled following an increase in the minimum wage. These results, presented in Table 9, offer offer little support for labor demand substitution. While the employment adjustments for higher skilled workers are larger (i.e. more positive) than for all workers together (or all low-skill workers), which is precisely what one would expect if demand substitution were taking place, the patterns are not statistically different from each other. Thus, like the wage and employment evidence from the SIPP, there is very little evidence in the CPS that demand substitution is taking place in any meaningful way.

Table 9: The Ripple Effect of Minimum Wages on Employment Levels Within Skill-Based Occupations in the CPS
2004 – 2007

	Hours of Work			**Total Employment**		
	All	**High Skill**	**Low Skill**	**All**	**High Skill**	**Low Skill**
	(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**
$w < 2 * mw$	-0.68**	-0.38	-0.66	-0.61**	-0.54*	-0.35
	(0.27)	(0.37)	(0.50)	(0.28)	(0.29)	(0.56)
$2 * mw \leq w < 3 * mw$	-0.35	-0.39	-0.28	-0.40*	-0.33	-0.42
	(0.23)	(0.28)	(0.30)	(0.22)	(0.21)	(0.26)
$3 * mw \leq w < 4 * mw$	0.19	0.56	0.76**	0.17	0.17	0.81***
	(0.20)	(0.35)	(0.30)	(0.23)	(0.26)	(0.30)
$4 * mw \leq w < 8 * mw$	0.32	0.35	0.35	0.40	0.33	0.30
	(0.31)	(0.62)	(0.33)	(0.32)	(0.30)	(0.34)

Note: Occupations within wage groupings are combined according to the average 2004 skill premium. The wage groupings differ in the CPS sample because these are average wages within an occupation and the sample sizes were too small using the groupings from the SIPP sample as in Table 4 and 5. The periods T, T+1, and T+2 are combined, so these estimates capture the aggregate effect across three years.

Taken together, the employment adjustment evidence from the CPS – like the wage and employment results from the SIPP – strongly supports the idea that labor supply substitution is taking place while labor demand substitution is not. Thus, the employment data in the CPS provide additional evidence that labor supply substitution is the primary cause of the ripple effect of minimum wages.

7 Concluding Remarks

The previous literature on the ripple effect has documented a short-lived spillover that is hypothesized to result from labor demand substitution away from the lowest skilled workers. In this paper, I use an extended hedonic wage model to show that workers (in addition to firms) also respond to changes in the minimum wage by re-optimizing their labor supply decisions because a rising minimum wage leads to falling compensating wage differentials at hedonically undesirable jobs. Thus, workers respond to a higher opportunity wage at hedonically desirable jobs by shifting their employment to these more desirable jobs. This decline in labor supply at hedonically undesirable jobs also leads to a ripple effect in wages.

Empirically, I seek to disentangle these two competing causes by testing the implications of my model and re-estimating the ripple effect with interaction terms that separately account for the effect of an individual's skills and the hedonic compensation associated with their occupation. In this regard, I document three important empirical results. First, I find a monotonic relationship between the hedonic compensation of an individual's occupation and the magnitude of the wage gains they experience following an increase in the minimum wage. On the other hand, an individual's skill premium has no effect on the realized magnitude of the ripple effect, except at very high wage levels. Second, I find that increases in minimum wages are associated with voluntary labor market transitions by low-skill workers away from hedonically undesirable jobs and towards hedonically more-desirable jobs that pay less. However, I find no pattern of voluntary transitions among higher skilled workers nor a pattern of involuntary transitions among lower skilled workers. Third, I find that this individual voluntary employment responses from the SIPP is evident in the aggregate state-level occupational data in the CPS. Indeed, I find that increases in the minimum wage are *not* associated with major losses in total employment but there is a clear pattern of resorting across occupations: with large employment declines at occupations with greater than average hedonic compensation and offsetting employment growth at occupations with less than average hedonic compensation.

All three of these empirical findings point to labor supply substitution as the primary cause of the ripple effect of minimum wages. In fact, I find very little evidence that labor demand substitution plays much of a role at all in bringing about ripple effect of minimum wages. Thus, this paper documents an economically significant labor supply response to the minimum wage where the optimal reemployment decisions of low wage workers propagate the ripple effect and lead to rising wages that affect approximately 30% of the labor market.

In the process of this analysis, I also re-estimate the ripple effect using data that better allows me to control for an individual's wage prior to the change in the minimum wage, and thus more accurately estimate the lagged ripple effect. Contrary to Neumark, Schweitzer, and Wascher (2004), I find that the ripple effect is much more persistent than previously believed and it does not exhibit the large subsequent negative effects that they document.

These two new findings – the importance labor supply substitution and a more persistent and positive ripple effect – suggest that a systematic reassessment of the utility gains associated with the ripple effect is warranted.

References

Aaronson, D. (2001): "Price Pass-Through and the Minimum Wage," *Review of Economics and Statistics*, 83(1), 158–169.

Aaronson, D., E. French, and J. MacDonald (2008): "The Minimum Wage, Restaurant Prices, and Labor Market Structure," *Journal of Human Resources*, 43(3), 688–720.

Addison, J. T., M. L. Blackburn, and C. D. Cotti (2012): "The Effect of Minimum Wages on Labour Market Outcomes: County-Level Estimates from the Restaurant-and-Bar Sector," *British Journal of Industrial Relations*, 50(3), 412–435.

——— (2013): "Minimum Wage Increases in a Recessionary Environment," *Labour Economics*, 23(0), 30–39.

Ahn, T., P. Arcidiacono, and W. Wessels (2011): "The Distributional Impacts of Minimum Wage Increases when both Labor Supply and Labor Demand are Endogenous," *Journal of Business & Economic Statistics*, 29(1), 12–23.

Allegretto, S. A., A. Dube, and M. Reich (2011): "Do minimum Wages Really Reduce Teen Employment? Accounting for Heterogeneity and Selectivity in State Panel Data," *Industrial Relations: A Journal of Economy and Society*, 50(2), 205–240.

Autor, D., A. Manning, and C. L. Smith (2010): "The Role of the Minimum Wage in the Evolution of US Wage Inequality over Three Decades: A Modest Re-Assessment," *NBER Working Paper*.

Brown, C. (1980): "Equalizing Differences in the Labor Market," *Quarterly Journal of Economics*, 94(1), 113–134.

——— (1999): "Minimum Wages, Employment, and the Distribution of Income," *Handbook of Labor Economics*, 3, 2101–2163.

Brown, C., C. Gilroy, and A. Kohen (1983): "Time-Series Evidence of the Effect of the Minimum Wage on Youth Employment and Unemployment," *Journal of Human Resources*, pp. 3–31.

Card, D., and A. Krueger (1994): "Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania," *American Economic Review*, 84(4), 772–793.

——— (1995): *Myth and Measurement: The New Economics of the Minimum Wage*. Princeton University Press.

Dickens, R., S. Machin, and A. Manning (1998): "Estimating the Effect of Minimum Wages on Employment From the Distribution of Wages: A Critical View," *Labour Economics*, 5(2), 109–134.

——— (1999): "The Effects of Minimum Wages on Employment: Theory and Evidence from Britain," *Journal of Labor Economics*, 17(1), 1–22.

Dickens, R., and A. Manning (2004): "Spikes and spill-overs: The impact of the national minimum wage on the wage distribution in a low-wage sector," *The Economic Journal*, 114(494), C95–C101.

DiNardo, J., N. Fortin, and T. Lemieux (1996): "Labor Market Institutions and the Distribution of Wages, 1973-1992: A Semiparametric Approach," *Econometrica*, 64(5), 1001–1044.

Dube, A., T. W. Lester, and M. Reich (2010): "Minimum Wage Effects Across State Borders: Estimates using Contiguous Counties," *The Review of Economics and Statistics*, 92(4), 945–964.

——— (2011): "Do Frictions Matter in the Labor Market? Accessions, Separations, and Minimum Wage Effects," *IZA Discussion Paper*.

Flinn, C. (2002): "Interpreting Minimum Wage Effects on Wage Distributions: A Cautionary Tale," *Annales d'Economie et de Statistique*, pp. 309–355.

——— (2006): "Minimum Wage Effects on Labor Market Outcomes under Search, Matching, and Endogenous Contact Rates," *Econometrica*, 74(4), 1013–1062.

Giuliano, L. (2013): "Minimum Wage Effects on Employment, Substitution, and the Teenage Labor Supply: Evidence from Personnel Data," *Journal of Labor Economics*, 31(1), 155–194.

Gramlich, E. (1976): "Impact of Minimum Wages on Other Wages, Employment, and Family Incomes," *Brookings Papers on Economic Activity*, 2(76), 409–451.

Grossman, J. (1983): "The Impact of the Minimum Wage on Other Wages," *Journal of Human Resources*, 18(3), 359–78.

Hirsch, B., B. Kaufman, and T. Zelenska (2011): "Minimum Wage Channels of Adjustment," *Andrew Young School of Policy Studies Research Paper Series*, (11-34).

Katz, L., and A. Krueger (1992): "The Effect of the Minimum Wage on the Fast-Food Industry," *Industrial and Labor Relations Review*, 46(1), 6–21.

Lang, K., and S. Kahn (1998): "The Effect of Minimum-Wage Laws on the Distribution of Employment: Theory and Evidence," *Journal of Public Economics*, 69(1), 67–82.

Lee, D. (1999): "Wage Inequality in the United States During the 1980s: Rising Dispersion or Falling Minimum Wage?," *The Quarterly Journal of Economics*, 114(3), 977–1023.

Machin, S., and A. Manning (1993): "The Effects of Minimum Wages on Wage Dispersion and Employment: Evidence from the UK Wages Councils," *Industrial & Labor Relations Review*, 47, 319.

Machin, S., A. Manning, and L. Rahman (2003): "Where the Minimum Wage Bites Hard: Introduction of Minimum Wages to a Low Wage Sector," *Journal of the European Economic Association*, 1(1), 154–180.

Meyer, R., and D. Wise (1983): "Discontinuous Distributions and Missing Persons: The Minimum Wage and Unemployed Youth," *Econometrica*, 51(6), 1677–1698.

Neumark, D., J. Salas, and W. Wascher (2013): "Revisiting the Minimum Wage-Employment Debate: Throwing out the Baby with the Bathwater?," Discussion paper, National Bureau of Economic Research.

Neumark, D., M. Schweitzer, and W. Wascher (2004): "Minimum Wage Effects throughout the Wage Distribution," *Journal of Human Resources*, 39(2), 425.

Neumark, D., and W. Wascher (1991): "Evidence on Employment Effects of Minimum Wages and Subminimum Wage Provisions from Panel Data on State Minimum Wage Laws," Discussion paper, National Bureau of Economic Research.

Neumark, D., and W. Wascher (1995): "Minimum-wage Effects on School and Work Transitions of Teenagers," *The American Economic Review*, 85(2), 244–249.

Portugal, P., and A. R. Cardoso (2006): "Disentangling the Minimum Wage Puzzle: An Analysis of Worker Accessions and Separations," *Journal of the European Economic Association*, 4(5), 988–1013.

Rosen, S. (1974): "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," *Journal of Political Economy*, 82(1), 34.

——— (1986): "The Theory of Equalizing Differences," *Handbook of Labor Economics*, 1, 641–692.

Stewart, M. B. (2004a): "The Employment Effects of the National Minimum Wage," *The Economic Journal*, 114(494), C110–C116.

——— (2004b): "The Impact of the Introduction of the UK Minimum Wage on the Employment Probabilities of Low-wage Workers," *Journal of the European Economic Association*, 2(1), 67–97.

Teulings, C. N. (2000): "Aggregation bias in elasticities of substitution and the minimum wage paradox," *International Economic Review*, 41(2), 359–398.

Welch, F. (1974): "Minimum Wage Legislation in the United States," *Economic Inquiry*, 12(3), 285–318.

Wicks-Lim, J. (2006): "Mandated Wage Floors and the Wage Structure: New Estimates of the Ripple Effects of Minimum Wage Laws," *PERI Woring Paper*.

A Appendix

Table A1: Occupations with the Highest and Lowest Hedonic Compensating Wage Differential

Highest Compensating Differentials	Lowest Compensating Differentials
ALL WORKERS	
Chemical Engineers	Postal Carriers
Aircraft Pilots	Supervisors of Correctional Officers
Respiratory Therapists	Tire Builders
Dental Hygienists	Postal Clerks
Industrial and Utility Electrical Repairers	Drawing Machine Setters
Chemists and Materials Scientists	Non-farm Animal Caretakers
Elevator Installers	Agricultural Inspectors
Nuclear Engineers/Technicians	Structural Metal Fabricators
Physician Assistants	Child Care Workers
Chemical Technicians	Counter Clerks
Computer Systems Managers	Advertising and Promotions Managers
Dentists	Supervisors of Landscaping Workers
Hazardous Materials Removers	Cost estimators
Diagnostic Technicians	Hairdressers, Hairstylists, and Cosmetologists
Power Plant Operators	Textile and Garment Presser
Massage Therapists	Preschool Teachers
Aircraft Mechanics	Appraisers and Assessors of real estate
Registered Nurses	Automotive Body Repairers
Millwrights	Veterinarians
Clinical Laboratory Technicians	Bookbinders
LOW-WAGE WORKERS ONLY: INDIVIDUALS PAID LESS THAN 2*MW	
Pilots and Flight Engineers	Non-farm Animal Caretakers
Chemists and Materials Scientists	Postal Mail Carriers
Chemical Technicians	Child Care Workers
Millwrights	Counter Clerks
Electrical Power-Line Installers and Repairers	Hairdressers, Hairstylists, and Cosmetologists
Paper Goods Machine Setters	Combined Food Preparation (Including Fast Food)
Diagnostic Technicians	Textile and Garment Presser
Aircraft Mechanic	Bakers
Printing Machine Operators	Dishwashers
Management Analysts	Preschool Teachers
Molders and Molding Machine Setters	Postal Service Clerks
Forest and Conservation workers	Cooks
Structural Iron and Steel Workers	Miscellaneous Agricultural Workers
First-line Supervisors Retail workers	Food Preparation Workers
Marketing and Sales Managers	Carpet and Tile Installers
Civil Engineers	Home Health Aides
Clinical Laboratory Technicians	Farmers and Ranchers
Tax Preparers	Cashiers
Police Officers	Parking Lot Attendants
Maintenance and Repair Workers	Supervisors of Food Preparation Workers

Note: These are the 20 occupations with highest and lowest average hedonic premium.
A minimum of 15 total observations is required for inclusion in this Table.

Table A2: Hedonic Compensation Coefficients by Wage Grouping

	Cramped Work Space/Awkward Positions	Exposed to Hazardous Conditions	Exposed to Hazardous Equipment	Exposed to Minor Burns/Cuts	Spend Time Kneeling Crouching	Exposed to Hot/Cold Temperatures	Wear Safety Equiptment	Exposed to Contaminents
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
All Workers	0.16***	0.08***	0.03***	-0.14***	-0.13***	-0.01***	0.05***	-0.08***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
$w < 1.15 * mw$	0.05***	0.02**	0.02**	-0.03***	-0.04***	-0.02***	0.01**	-0.01
	(0.012)	(0.008)	(0.006)	(0.006)	(0.007)	(0.008)	(0.004)	(0.007)
$1.15 * mw \leq w < 1.75 * mw$	0.05***	0.025***	0.035***	-0.055***	-0.055***	-0.01**	0.025***	-0.035***
	(0.005)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.002)	(0.003)
$1.75 * mw \leq w < 2.5 * mw$	0.04***	0.03***	0.02***	-0.05***	-0.04***	0.01**	0.02***	-0.03***
	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.002)	(0.003)
$2.5 * mw \leq w < 6 * mw$	0.09***	0.05***	-0.01**	-0.09***	-0.07***	-0.01*	0.04***	-0.06***
	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.002)	(0.003)

Note: These are the hedonic compensation coefficients from the estimates of equation (5), on different sub-samples from the SIPP

Table A3: Federal & State Minimum Wage Increases 2003-2007

States with Changes in the Minimum Wage over 2004-2007

	U.S.	AR	AZ	CA	CO	CT	DC	DE	FL	IA	IL	HI	MA	ME	MD	MI
2003	$5.15	$5.15	$5.15	$6.90	$5.15	$6.90	$6.15	$6.15	$5.15	$5.15	$5.15	$6.25	$6.75	$6.25	$5.15	$5.15
2004						$7.10					$5.50			$6.35		
2005							$6.60		$6.15		$6.50			$6.50		
2006		$6.25				$7.40	$7.00		$6.40			$6.75		$6.75	$6.15	$6.95
2007	$5.85		$6.75	$7.50	$6.85	$7.65		$6.65	$6.67	$6.15	$7.50	$7.25	$7.50	$7.00		$7.15

	MN	MO	MT	NV	NJ	NY	NC	OH	OR	PA	RI	VT	WA	WV	WI
2003	$5.15	$5.15	$5.15	$5.15	$5.15	$5.15	$5.15	$5.15	$6.90	$5.15	$6.15	$6.25	$7.01	$5.15	$5.15
2004									$7.05		$6.75	$6.75	$7.16		
2005	$6.15				$6.15				$7.25			$7.00	$7.35		$5.70
2006				$6.15	$7.15				$7.50			$7.25	$7.63	$5.85	$6.50
2007		$6.50	$6.15	$6.33		$7.15	$6.15	$6.85	$7.80	$7.15	$7.40	$7.53	$7.93	$6.55	

Note: The first column presents the minimum wage in 2003 for states that changed their minimum wage during the period 2004-2007. Empty cells reflect no change in the minimum wage.

Table A4: The Ripple Effect of Minimum Wages
Effects on Hours of Work and Weekly Earnings – All Workers

	Hours Worked				Weekly Earnings			
Wage Grouping	**T-1**	**T**	**T+1**	**T+2**	**T-1**	**T**	**T+1**	**T+2**
	(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**
$mw \leq w < 1.05 * mw$	-0.10	0.08	0.27	-0.24	0.21	0.93**	0.80*	-0.46
	(0.25)	(0.30)	(0.46)	(0.35)	(0.26)	(0.39)	(0.42)	(0.40)
$1.05 * mw \leq w < 1.15 * mw$	-0.03	-0.12	0.04	-0.13	0.23	0.05	0.73*	0.19
	(0.16)	(0.20)	(0.23)	(0.28)	(0.18)	(0.28)	(0.42)	(0.32)
$1.15 * mw \leq w < 1.5 * mw$	-0.01	-0.10	-0.01	0.18	-0.01	0.08	0.34*	0.53***
	(0.08)	(0.11)	(0.14)	(0.15)	(0.09)	(0.15)	(0.20)	(0.14)
$1.5 * mw \leq w < 1.75 * mw$	-0.04	0.01	-0.09	0.17	-0.08	0.12	-0.05	0.46*
	(0.05)	(0.08)	(0.08)	(0.25)	(0.07)	(0.08)	(0.11)	(0.24)
$1.75 * mw \leq w < 2 * mw$	-0.04	-0.06	0.17**	0.11	-0.03	0.05	0.30**	0.29
	(0.06)	(0.08)	(0.07)	(0.18)	(0.08)	(0.15)	(0.11)	(0.27)
$2 * mw \leq w < 2.5 * mw$	-0.03	-0.03	-0.01	-0.01	-0.06	-0.07	-0.09	0.33
	(0.03)	(0.04)	(0.07)	(0.09)	(0.06)	(0.07)	(0.12)	(0.26)
$2.5 * mw \leq w < 4 * mw$	-0.01	0.08	-0.01	0.06	-0.01	0.08	-0.03	0.32
	(0.03)	(0.04)	(0.06)	(0.09)	(0.05)	(0.07)	(0.10)	(0.26)
$4 * mw \leq w < 6 * mw$	0.03	0.10	0.04	0.13*	0.02	0.13	0.01	-0.41***
	(0.03)	(0.04)	(0.09)	(0.07)	(0.06)	(0.16)	(0.22)	(0.16)

Notes: The ripple effect is estimated as the elasticity of weekly hours worked (earnings) following an increase in the minimum wage. Period T refers to the period just following the increase in the minimum wage; T-1(T+1) is 1 year prior to (after) the increase; etc.

Table A5: Ripple Effect Estimates in the SIPP
Controlling for Variation Across Skill and Hedonic Compensation Indices

		No Interactions				Skill and Hedonic Interactions			
	Wage Group	**T-1**	**T**	**T+1**	**T+2**	**T-1**	**T**	**T+1**	**T+2**
		(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**
Changes in the Minimum Wage	$w < 1.15 * mw$	0.17**	0.35***	0.58***	0.21**	-0.32	0.33	0.01	0.67
		(0.07)	(0.07)	(0.09)	(0.10)	(0.22)	(0.27)	(0.40)	(0.56)
	$1.15 * mw \leq w < 1.75 * mw$	0.00	0.14***	0.17***	0.15**	-0.18**	0.08	0.15	-0.27
		(0.02)	(0.04)	(0.04)	(0.06)	(0.07)	(0.09)	(0.24)	(0.24)
	$1.75 * mw \leq w < 2.5 * mw$	0.00	0.01	0.07	0.20**	-0.22	-0.11	-0.37	1.14***
		(0.04)	(0.07)	(0.07)	(0.10)	(0.14)	(0.19)	(0.43)	(0.41)
	$2.5 * mw \leq w < 6 * mw$	-0.01	0.00	0.02	-0.03	-0.53***	-0.33*	-0.29	-0.18
		(0.03)	(0.05)	(0.06)	(0.06)	(0.14)	(0.19)	(0.33)	(0.51)
Skill Index X Changes in the Minimum Wage	$w < 1.15 * mw$					2.21*	-2.13	0.83	-2.65
						(1.14)	(1.58)	(2.70)	(2.34)
	$1.15 * mw \leq w < 1.75 * mw$					0.12	0.15	-0.51	1.23
						(0.27)	(0.44)	(0.76)	(0.85)
	$1.75 * mw \leq w < 2.5 * mw$					0.54	0.65	0.41	-2.19*
						(0.36)	(0.74)	(1.07)	(1.13)
	$2.5 * mw \leq w < 6 * mw$					1.45***	0.87**	1.05	0.16
						(0.41)	(0.44)	(1.25)	(2.90)
Hedonic Compensation Index X Changes in the Minimum Wage	$w < 1.15 * mw$					2.13	5.10***	4.61	0.80
						(1.50)	(1.23)	(3.38)	(4.02)
	$1.15 * mw \leq w < 1.75 * mw$					1.30**	0.03	0.65	1.57
						(0.52)	(0.77)	(1.10)	(1.73)
	$1.75 * mw \leq w < 2.5 * mw$					0.95	0.04	2.82	-4.65
						(0.68)	(0.64)	(2.39)	(3.18)
	$2.5 * mw \leq w < 6 * mw$					0.75	0.51	0.53	0.55
						(0.25)	(0.48)	(0.60)	(0.63)

Note: The Skill Index is simply the estimated compensation associated with an individual's education and labor market experience. Similarly, the Hedonic Compensation Index is the estimated hedonic compensation associated with the hedonic characteristics of an individual's occupation in the previous period. Both of these indices are included separately and then crossed with changes in the minimum wage to understand how the ripple moves among skill and hedonic groups.

Table A6: The Ripple Effect of Total Employment Hours by Occupation in the CPS
2004 – 2007: by Wage Grouping

		No Interactions				Skill and Hedonic Interactions			
	Wage Group	**T-1**	**T**	**T+1**	**T+2**	**T-1**	**T**	**T+1**	**T+2**
		(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**
Changes in the Minimum Wage	$w < 2 * mw$	-0.05	-0.19	-0.20	-0.13	-0.03	-0.18	-0.19	-0.14
		(0.12)	(0.17)	(0.24)	(0.26)	(0.11)	(0.17)	(0.23)	(0.22)
	$2 * mw \leq w < 3 * mw$	-0.11	-0.12	-0.19	-0.03	-0.11	-0.13*	-0.24*	-0.13
		(0.07)	(0.09)	(0.15)	(0.14)	(0.07)	(0.11)	(0.14)	(0.15)
	$3 * mw \leq w < 4 * mw$	-0.04	0.03	0.21	0.04	-0.04	0.02	0.15	-0.01
		(0.11)	(0.16)	(0.22)	(0.31)	(0.11)	(0.16)	(0.23)	(0.35)
	$4 * mw \leq w < 8 * mw$	-0.03	-0.02	-0.11	-0.47	-0.03	-0.03	-0.12	-0.45
		(0.11)	(0.21)	(0.18)	(0.32)	(0.10)	(0.21)	(0.17)	(0.28)
Skill Index X Changes in the Minimum Wage	$w < 2 * mw$					-0.01	-0.05	0.18	-0.17
						(0.09)	(0.08)	(0.21)	(0.16)
	$2 * mw \leq w < 3 * mw$					0.04	0.24	0.32**	0.42*
						(0.12)	(0.11)	(0.15)	(0.22)
	$3 * mw \leq w < 4 * mw$					0.00	0.03	0.13*	0.08
						(0.07)	(0.08)	(0.07)	(0.29)
	$4 * mw \leq w < 8 * mw$					-0.04	-0.04	-0.16	-0.45***
						(0.08)	(0.13)	(0.13)	(0.11)
Hedonic Compensation Index X Changes in the Minimum Wage	$w < 2 * mw$					-0.93	-3.79**	-4.28*	-8.16*
						(2.49)	(1.77)	(2.52)	(4.94)
	$2 * mw \leq w < 3 * mw$					-1.79	-5.03***	-5.58**	-1.42
						(1.38)	(0.87)	(2.10)	(5.35)
	$3 * mw \leq w < 4 * mw$					-0.90	-2.68**	-3.04**	2.48
						(0.94)	(0.98)	(1.49)	(2.45)
	$4 * mw \leq w < 8 * mw$					-0.72	2.52	0.93	3.34
						(2.15)	(1.58)	(2.35)	(2.62)

Note: The Skill Index is estimated similarly to equation (6) using the CPS. The Hedonic Compensation Index is the implied hedonic compensation associated with estimates of equation (6) on the SIPP sample. The same values are applied to the Current Population Survey data. The wage groupings differ in the CPS sample because these are average wages within an occupation and the sample sizes were too small using the groupings from the SIPP sample as in Table 4 and 5. Both of these indices are included separately and then crossed with changes in the minimum wage to understand how employment adjusts across skill and hedonic groups.

Table A7: The Ripple Effect of Total Employment Levels by Occupation in the CPS 2004 – 2007: by Wage Grouping

		No Interactions				Skill and Hedonic Interactions			
	Wage Group	**T-1**	**T**	**T+1**	**T+2**	**T-1**	**T**	**T+1**	**T+2**
		(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**
Changes in the Minimum Wage	$w < 2*mw$	-0.06	-0.23	-0.09	-0.06	-0.04	-0.25	-0.11	-0.07
		(0.14)	(0.19)	(0.27)	(0.29)	(0.13)	(0.19)	(0.26)	(0.25)
	$2*mw \leq w < 3*mw$	-0.11	-0.14*	-0.17	-0.06	-0.11	-0.15	-0.21	-0.17
		(0.07)	(0.08)	(0.15)	(0.15)	(0.07)	(0.11)	(0.14)	(0.17)
	$3*mw \leq w < 4*mw$	-0.04	0.05	0.20	0.13	-0.04	0.03	0.14	0.10
		(0.11)	(0.17)	(0.22)	(0.33)	(0.11)	(0.17)	(0.22)	(0.38)
	$4*mw \leq w < 8*mw$	-0.04	-0.01	-0.08	-0.61**	-0.03	-0.02	-0.09	-0.59**
		(0.10)	(0.20)	(0.16)	(0.30)	(0.09)	(0.20)	(0.16)	(0.28)
Skill Index X Changes in the Minimum Wage	$w < 2*mw$					-0.04	-0.14	0.10	-0.29**
						(0.10)	(0.09)	(0.17)	(0.12)
	$2*mw \leq w < 3*mw$					0.05	0.26**	0.39**	0.41*
						(0.11)	(0.11)	(0.17)	(0.22)
	$3*mw \leq w < 4*mw$					0.01	0.03	0.15**	0.01
						(0.07)	(0.08)	(0.07)	(0.29)
	$4*mw \leq w < 8*mw$					-0.05	-0.04	-0.10	-0.39***
						(0.07)	(0.13)	(0.13)	(0.12)
Hedonic Compensation Index X Changes in the Minimum Wage	$w < 2*mw$					-0.70	-8.11***	-9.04***	-9.45*
						(2.57)	(1.80)	(3.42)	(5.80)
	$2*mw \leq w < 3*mw$					-2.16	-5.33***	-6.34***	-2.33
						(1.44)	(0.91)	(2.00)	(4.59)
	$3*mw \leq w < 4*mw$					-0.90	-2.91***	-3.02**	0.94
						(0.90)	(1.01)	(1.40)	(2.38)
	$4*mw \leq w < 8*mw$					-1.28	1.83	0.33	3.74
						(2.15)	(1.48)	(2.12)	(2.30)

Note: The Skill Index is estimated similarly to equation (6) using the CPS. The Hedonic Compensation Index is the implied hedonic compensation associated with estimates of equation (6) on the SIPP sample. The same values are applied to the Current Population Survey data. The wage groupings differ in the CPS sample because these are average wages within an occupation and the sample sizes were too small using the groupings from the SIPP sample as in Table 4 and 5. Both of these indices are included separately and then crossed with changes in the minimum wage to understand how employment adjusts across skill and hedonic groups.