Pay Cycles:

Individual and Aggregate Effects of Paycheck Frequency

[*Job Market Paper*]

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Abstract

This paper shows that the frequency at which workers are paid affects the within-month patterns of both household expenditure and aggregate economic activity. To identify causal effects, I exploit two novel sources of exogenous variation in pay frequency in the US. First, using an as-good-as-random variation in the pay frequency of retired couples, I show that those who are paid more frequently have smoother expenditure paths. Second, I take advantage of cross-state variation in labor laws to compare patterns of economic activity in states in which the frequency with which wages are paid differs. I document that low pay frequencies lead to within-month business cycles when many workers are paid on the same dates, which in turn generates costly congestion in sectors with capacity constraints. These findings have important policy implications for contexts where firms and workers do not internalize such congestion externalities as this situation leads to market equilibria with suboptimally low pay frequencies and few paydays.

Keywords: Pay frequency, within-month business cycles, congestion.

JEL Classification: J33, E21, E32

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I. Introduction

Across the world, workers are paid at different frequencies. In many countries the custom is to pay wages once a month, while in others workers are paid twice a month or every week. Variations in wage pay frequency appear even within countries (e.g. in the United States workers receive their salaries at different frequencies depending on state-level regulation). Looking at this variation, a natural question is whether pay frequency affects consumer decisions on expenditure, and thus has economic consequences. Standard theory suggests that it should not: wages and paydays are perfectly anticipated, and the Permanent Income Hypothesis predicts that the timing of consumption should not track the predictable timing of income.[1]

However, there is an extensive literature showing that household expenditure and even mortality rise immediately after income receipt (Stephens, 2003; Stephens, 2006; Stephens et al., 2011; Mastrobuoni and Weinberg, 2009; Shapiro, 2005; Evans and Moore, 2011; Evans and Moore, 2012 and Andersson et al., 2015). Such spikes could be a consequence of low pay frequencies, as proposed by Van Wesep and Parsons (2013). More precisely, these authors show theoretically that infrequent payments lead to cycles in individual consumption if consumers are hyperbolic discounters (i.e. they have a taste for immediate gratification and a long-run preference to act patiently).[2]

In this paper, I argue that the frequency at which someone is paid does matter, and not only because it could affect her consumption pattern, but also for its impact on the aggregate activity. If infrequent payments lead to cycles in the expenditure of some households, this non-smoothing behavior would translate into the aggregate economy, generating within-month business cycles if many of these consumers are paid at a low frequency and at the same time. Such cycles are particularly problematic for sectors with capacity constraints and relevant menu

1. The terms "infrequent payments" and "low pay frequencies" are used interchangeably throughout the paper.

2. Anecdotal evidence reinforces the idea that employees might care about their own pay frequencies. For instance, at the end of the nineteenth century workers in several US states lobbied for receiving their wages weekly instead of monthly (Paterson, 1917), which resulted in most states adopting laws requiring more frequent payments.

costs (restaurants, groceries, hospitals, etc), because of the congestion costs they face during the peaks of activity.[3] Thus, how frequently an individual receives paychecks might affect not only her but also others' wellbeing, the latter through congestion externalities.

The first part of this paper is devoted to showing empirically that the frequency of pay does affect the patterns of household expenditure. This gives the basis for the second part, which studies whether such individual effects translate into the aggregate economy when everybody is paid on the same dates. To find causal effects, I exploit exogenous variation in the frequency of payments in the United States, at both household and state levels.

At the household level, I take advantage of (*as-good-as-random*) variation in the pay frequency of a set of households that, by chance, get paid once or twice per month. These are households with both spouses retired, which I call *retired couples*. In the United States, Social Security benefits of individuals retired after 1997 are paid in different weeks, depending on the recipient's birthday: retirees are paid on either the 2nd, the 3rd or the 4th Wednesday of each month, depending on whether their day of birth is on the 1st-10th, 11th-20th, or 21st-31st, respectively.[4] This variation in the timing of pay generates two groups of retired couples: those with both spouses receiving their paychecks on the same day (households with *one payday*), and those with spouses paid in different weeks of the month (*two paydays*). This quasi-random assignment of pay frequency allows me to test whether different frequencies of payments produce different within-month expen-

3. A recent anecdote of stores in Michigan asking for an increase of the frequency at which their consumers receive their paychecks, illustrates the relevance of these aggregate effects. In 2008, the Senate of Michigan presented a bill asking to change the food stamp distribution from a single payment on the first week of the month to semi-monthly payments. The bill was advocated for retailers and suppliers, who indicated that food stamp recipients spend most of their benefits shortly after they are paid, generating (congestion) problems to stores in terms of staffing, cash flow, inventory and quality control. The rationale for this bill presented by the Senate was that the semi-monthly distribution of food stamps would address the concerns of grocers as well as the needs of recipients to smooth consumption (New York Times, 2006 and Bill 120 Michigan, 2008).

4. Individuals retired before 1997 are all paid on the 3rd of the month. Because they are systematically older than pensioners paid on Wednesdays we cannot include them in the analysis, otherwise the assignment of the number of paydays would not be as-good-as-random. Nevertheless, results are robust to the inclusion of couples in which at least one spouse retired before 1997.

diture profiles.[5]

Using data from the Consumer Expenditure Survey (CEX), I compare the pattern of daily expenditure of retired couples with one payday to the pattern observed in households with two paydays. Results show that not all households smooth expenditure between paychecks, but the ability to smooth depends on the *frequency of payments*: retired couples with two paydays have a smooth expenditure path over the month, while households receiving their income in only one payment spend significantly more in the week they are paid than in weeks they are not. More importantly, these effects are particularly significant for poorer households, which are more likely to be credit constrained and may have higher short-term discount rates (Mani et al., 2013).[6]

To the best of my knowledge this is the first empirical paper that identifies the causal effects of different pay frequencies on the expenditure smoothing behavior of households, and shows that households can smooth expenditure within the month if they receive frequent payments. A previous attempt was made by Stephens et al. (2011), who study whether the consumption of Japanese pensioners responds differently to quarterly and bi-monthly benefit receipts. However, the authors make a caveat to their findings and explain that –under bi-monthly payments– they cannot provide a powerful test of consumption smoothing.[7]

5. The setting of US Social Security payments I exploit –with enough variation in the timing of pay– also allows me to disentangle the effect of paycheck receipt from any other mechanism that could drive changes in expenditure after payment, e.g. beginning of the month effects. Previous research analyzing the link between consumption after the arrival of paychecks (from pensions or food stamps) could not control for week fixed effects because in their settings there was no variation in paydays. Not enough variation leads to confounding effects with beginning of the month effects. In addition, I analyze recent years, thus my results show that even in a period with much more access to technology –which may help people to smooth their consumption– individuals may still have problems smoothing their consumption when they receive their pay at low frequencies. While my research covers the period from the late 1990 to late 2000, previous literature used data for the late '80s to the beginning of the '90s. Credit cards, which could be useful to smooth consumption, were more common in the period I analyze than in these previous years.

6. An underlying assumption in this exercise is that these couples pool their income, at least when deciding about the outcomes we are interested in. Taking advantage of variations in the timing at which spouses receive their paychecks, I proposed a novel identification strategy to test empirically whether couples pool income, and using this test I could not reject income pooling (See Section III.D.2.).

7. Stephens et al. (2011) notice that they do not have enough variation to identify the effects of this change in pay frequency, because they use monthly expenditure data and under bi-monthly

To analyze the aggregate effects of different pay frequencies, I exploit variation in the legislation of wage payment frequency across US states. I compare the within-month trends of several proxies of daily economic activity – i.e. time spent shopping, air pollution, and traffic accidents– in states requiring weekly or semi-monthly payments. Results indicate that in states requiring workers to be paid twice a month, there is a significant increase in economic activity during the usual pay weeks (the first week of the month and the week of the 15th), while within-month economic activity is smoother in states with weekly payments. This exercise allows us to check that the results found in the sample of retired couples are informative about the effects of pay frequency on the rest of the population receiving periodic payments. Moreover, and more importantly, it gives us evidence about the impact of pay frequency at aggregate levels, putting particular emphasis on sectors where congestion is an important issue.

These results are related to the findings of Hastings and Washington (2010) and Evans and Moore (2012) who, respectively, document an increase in grocery purchases –together with food prices– and a spike in mortality, at the beginning the month. Evans and Moore (2012) suggest that such peaks in mortality may be due to short-term variation in levels of economic activity during the first days of the month. My paper shows that such cycles are explained by the timing and, more importantly, the frequency of pay. Thus, the within-month cycles in aggregate activity exists under low pay frequency schemes, but they disappear if workers are paid frequently enough.

Of course, the monthly cycles analyzed in this paper emerge not only because of the low frequency of wages but for the conjunction of low pay frequencies and the *timing* of such payments, i.e. the fact that everybody gets the paycheck on the same date. The same natural experiments I exploit to analyze the impacts of pay frequencies also provide variations in how disperse are the paydays over the month. Drawing from such exogenous variations in the timing of pay I document that

payments the paychecks are delivered on the middle of the month (which means that the average number of days since check receipt is the same in the month of check receipt and in the other months).

under a low pay frequency scheme the aggregate cycles can disappear if workers are paid on different days: if paydays are spread over the month the aggregation of the referred cyclical individual expenditure do not generate aggregate cycles.

More precisely, using the whole sample of retired couples with one payday and taking advantage of the variation in the timing of pay (3rd of the month, 2nd, 3rd and 4th Wednesdays), I show that even under a low pay frequency scheme - which leads to individual expenditure cycles- the aggregate expenditure of households would be smooth if the paydays are evenly spread over the month. For instance, when we only analyze the sample of couples receiving paychecks on the 3rd of the month, we find that their aggregate expenditure is significantly larger at the beginning of the month. However, for the case of couples with paychecks distributed on the 2nd, 3rd or 4th Wednesdays, we observe a smoother aggregate expenditure over the month, and if something the expenditure is smaller during the first days when no one receive paychecks. Overall, by pooling all these households together we observe that the within-month cycles disappear when retired couples get the paychecks only once a month but have paydays on different weeks. Consistently with these results, I also show that in states requiring biweekly payments the aggregate economic activity is relatively stable over the month.[8] Although in these states workers would receive checks with approximately the same frequency as in states with semi-monthly payments (every 2 weeks), the paydays are not the same for everyone as in the case of a semi-monthly pay cycle, resulting in a smoother aggregate economic activity.[9]

To discuss the welfare effects of the cyclicity generated by low pay frequencies and the concentration of paydays, I extend the model of Van Wesep and Parsons (2013) by incorporating congestion costs. In this framework, the short-run impatience of quasi-hyperbolic consumers leads to an excessive accumulation of purchases immediately after they are paid. Thus, paying them at low frequen-

8. Except for the case of traffic accidents, with higher levels at the beginning of the month (see Section V.).

9. With a biweekly pay schedule each company chooses a set day and issues payment every other week on that day; in the semi-monthly pay schedule paydays are usually set on the 1st and 15th of the month for everybody.

cies and on the same dates causes cycles on aggregate expenditure that –during the peaks– generate congestion in sectors with capacity constraints. The model sheds light on two potential failures that explain why the frequency of payment may need to be regulated: an individual failure (attributable to time-inconsistent preferences), and a market failure (attributable to congestion externalities). Thus, although increasing pay frequency could be welfare-improving under several circumstances –even when it increases labor costs from processing more paychecks–, neither firms nor workers have the right incentives to implement higher frequencies when needed. Workers are naive (i.e. overconfident about their future behavior), so they are not aware of their time inconsistency and do not recognize that a higher pay frequency would directly improve their welfare by helping them to smooth consumption. In addition, neither workers nor firms internalize the negative impact that their pay scheme have on sectors with capacity constraints, through congestion effects.[10] Therefore, the market equilibrium would yield suboptimally low frequencies of pay and not enough paydays, which calls for policy interventions.

At least two possible welfare-improving interventions come out under this framework. More frequent payments (e.g. weekly paychecks instead of monthly) could raise welfare in a context where consumers are very (short-run) impatient, and/or congestion is too costly, and processing more payments is cheap enough (low transaction costs). If instead transaction costs are high, an alternative policy is to spread the paydays of different firms over the month (similar to what resulted from the biweekly pay cycles in the US). This policy should not significantly affect transactions costs, yet it would tackle the congestion problem by smoothing aggregate activity. Moreover, it would also act as an increase in pay frequency for households with at least two earners receiving their checks in different days, which – assuming (some) income pooling– would help many households to further smooth their expenditure over the month.[11]

10. The coordination problem arises first because not all firm's consumers are firm's workers, so even a firm with capacity constraints will not experience the potential negative effects generated by their workers' consumption cycles; and second because the within month cycle in purchases generated by their workers with such expenditure patterns do not negatively impact their own production costs if these firms do not have congestion problems.

11. Under this payment scheme, some costs from coordination failures could arise if quasi-

The rest of the paper is organized as follows. Section II. provides the conceptual framework. Section III. presents the empirical analysis of pay frequency's impact on household expenditure. Section IV. is devoted to a study of the aggregate effects of different pay frequencies in settings where everybody shares the paydays, while Section V. analysis the role of the timing of pay. Section VI. concludes by discussing some policy implications.

II. Conceptual Framework

In this section I present a simple theoretical framework to map out the relationship between frequency of wage payments, expenditure patterns of households and aggregate economic activity. This framework helps us to interpret the main results of the empirical analysis, and to understand how total welfare could vary under different pay frequencies and why the frequency of payment might need to be regulated.

I focus in one of the possible mechanisms that link frequency of wage payments and household expenditure cycles: individuals with short-run impatience that over spend immediately they are paid. There could be other possible explanations for the link between expenditure patterns and pay frequency, e.g., spending more money immediately after being paid can be optimal in the presence of high inflation (Barro, 1970). Nevertheless, it is important to note that no matter what generates the cycle in individual expenditure, the qualitative predictions of the aggregate effects of pay frequency and its congestion costs are the same.

The model is based on Van Wesep and Parsons (2013), and I enrich it by including capacity constraints in one sector in order to analyze the role of congestion costs on total welfare under different frequencies of wage payments. I also assume that everybody receives the paychecks on the same dates, as it is common in many

hyperbolic consumers enjoy doing activities (spending money) together. However, it could be argued that at least some part of the consumer's network would be paid on the same dates (co-workers). Coordination failures could be incorporated in the model and, when deciding about this proposed policy, the social planner should have to trade-off between the welfare gains from reducing congestion and time-inconsistency problems, versus the losses generated by being unable to coordinate the time of expenditure.

countries. The key ingredients of the model are naive consumers with short-run impatience plus self-control problems, whose behaviors generate negative externalities through congestion effects. Individuals with short-term impatience and self-control problems (quasi-hyperbolic discounting) may exhibit cyclical consumption paths if they do not receive paychecks frequently enough. Thus, if these workers are paid at a low frequency and all on the same dates, their behavior may generate aggregate consumption cycles resulting in an excessive accumulation (congestion) of purchases immediately after they are paid.

Therefore, higher pay frequencies could be welfare-improving if infrequent payments generate significant welfare losses to individuals that are not able to smooth consumption; and/or the congestion costs generated during paydays are important, but it is too costly to adjust factors or prices to make agents internalize these negative externalities.

However, this adjustment of pay frequency might not happen without a regulation that enforces more frequent payments. Without such intervention, firms and workers acting individually would lead to a market equilibrium with a sub-optimally low pay frequency. The inefficiency arises because, on the one hand, a higher pay frequency implies an increase in labor costs.[12] On the other hand, neither workers nor firms internalize the benefits of increasing their pay frequency: (a) workers are naive (overconfidence about their future behavior);[13] (b) firms and workers do not take into account the negative impact that their low frequencies of pay could have on other sectors with capacity constraints (external cancongestion costs).[14] Then, under this framework agents do not have incentives to increase

12. For firms, there is a higher cost of processing paychecks more frequently, because every time workers are paid firms pay a cost associated with processing a payroll (costs of printing checks for employees, direct deposit costs charged by banks and time spent by an employee or bookkeeper to calculate the gross pay, deductions and withholding, and net pay). Transaction costs probably also increase for employees, who may have to pay an opportunity cost associated with cashing the check (fees and/or time). Technological advances are significantly decreasing these administrative and transaction costs.

13. For these workers, a regulation that increases pay frequency would have the role of a commitment device, externally imposed to overcome the self-control problems of consumers.

14. The coordination problem arises because for each firm not all of its consumers are also their own workers, or because the within month cycle in purchases generated by their workers with self-control problems does not negatively impact their own production costs (e.g. no capacity constraints).

pay frequency, even when it would be socially optimal, leaving room for policy intervention.[15]

II.A. *Setup*

The population consists of a mass one of identical consumers with discount rates that are much greater in the short-run than in the long-run: they have a short-run preference for instantaneous gratification and a long-run preference to act patiently. The lack of self-control of these consumers is what drives the link between frequency of wage payments and cycles in expenditure. Short-run impatience is captured by consumers with quasi-hyperbolic discount functions – $\beta < 1$ in equation (1). Time is finite and discrete, it begins at period 1, and there is no uncertainty.[16]

The representative consumer knows her income in advance and derives utility from a stream of consumption at different dates. To derive close-form solutions, I assume that the representative consumer has logarithmic utility function and that her preferences are time-additive (congestion costs will be introduced later).[17] Then, consumer's utility at time t can be expressed as:

$$U_t \quad = \quad log(c_t) + \beta \sum_{s=1}^{T-t} log(c_{t+s}) \tag{1}$$

As time progresses, the individual changes her mind about the relative values of consumption at different points in time, because $\beta < 1$. However, she is naive: she acts as if her future selves will be willing to follow through on her current plans. Without loss of generality, I assume there are liquidity constraints, but saving (s)

15. Under infrequent frequently but paying workers in different periods (i.e. spreading payments during the month) would also reduce the within-month business cycles generated by low pay frequencies. However, paying more frequently to each individual would have a positive impact on both sectors with capacity constraints –which would face a smoother pattern of activity– and consumers with short-run impatience who would benefit from a self-control device that would force them to smooth expenditure.

16. As in Van Wesep and Parsons (2013), I do not consider issues of moral hazard or risk in the production process, nor do I address the use of contracts to screen workers.

17. W.l.g. I assume δ (long-term discount factor) is the same for the consumer and for the firm, and that δ=1.

is allowed: individual enters period t with s_{t-1} ($s_{t-1} \geq 0$).

There are many firms producing the consumption good in a competitive market. Therefore, firms are wage and price takers, and price is fixed over the periods and normalized to 1. Each firm hires a worker for T periods.[18] Every time the worker is paid the firm also has to pay a cost γ to make the payment.[19] I define w as the wage costs paid every period, before deducting transaction costs. Therefore, if the worker is paid every F periods, every time she gets a paycheck she receives $Fw - \gamma$.

Solving the model by backward induction from the day before the next paycheck gives as a result a consumption path that is decreasing over time within the time period of pay. Equations (2) and (3) are the outcome of the maximization problem, and they show how consumption in each period depends on the frequency of payment. Figure A.1, in the Appendix, shows examples of the pattern of daily consumption under different frequencies of wage payment. For higher F (low pay frequency) or smaller β (high short-term impatience), the variance of consumption increases.[20]

$$c_1 = \left(\frac{Fw - \gamma}{1 + (F-1)\beta} \right) \tag{2}$$

$$c_i = \left(\frac{Fw - \gamma}{1 + (F-i)\beta} \right) * \left[\prod_{j=1}^{i-1} \frac{(F-j)\beta}{1 + (F-j)\beta} \right] \quad for\ i \in \{2, 3, ..., F\} \tag{3}$$

To keep the model simple, I discuss a three period model ($T = 3$), which is the shortest possible time period that generates time inconsistency effects.[21] I analyze the implied mechanisms of the model and welfare effects under two alternative frequencies of payment: being paid with a lump-sum payment ($F = 3$) or being

18. I assume that the contract offered and reservation utility are such that the worker always accepts the contract.

19. The cost of processing these payments (γ) includes the cost of printing checks for employees, direct deposit costs charged by banks and time spent by an employee or bookkeeper to calculate the gross pay, deductions and withholding, and net pay. These costs have significantly decreased over time.

20. Proofs can be found in Appendix A of Van Wesep and Parsons (2013).

21. W.l.g I assume that the agent dies at the end of period 3.

paid every period ($F = 1$). Proofs of the results can be found in the Appendix, Section D..

II.B. *Three-Periods Model Without Congestion Costs*

When the representative worker is paid at a low frequency of payment (with one upfront pay of $3w-\gamma$ at t=1), the consumption path chosen by the naive agent with self-control problems is: $c_1^* = \frac{3w-\gamma}{(1+2\beta)}$, $c_2^* = \frac{2\beta(3w-\gamma)}{(1+2\beta)(1+\beta)}$, and $c_3^* = \frac{2\beta^2(3w-\gamma)}{(1+2\beta)(1+\beta)}$

Now consider that the representative worker receives her salary every period t. In particular, every time she is paid she receives $w - \gamma$. Solving the model by backward induction, we get a constant consumption path: $c_1^* = c_2^* = c_3^* = w - \gamma$

Figure A.2 in the Appendix compares the consumption paths chosen by the representative worker for different levels of β's under the two payments schemes. When the agent receives one upfront pay, the higher the short-term impatience (low β), the higher is the variance of consumption (there is more consumption immediately after receiving the payment). Consumption paths are similar under both payments schedules when the level of short term impatience is low (high β). The last panel of Figure A.2 shows that total consumption decreases when wages are paid more frequently because of the higher transaction costs (γ) which are net losses for the economy.

II.B.1. Welfare Analysis

Since time-inconsistent preferences imply that a person evaluates her well-being differently at different times, welfare comparisons when individuals have quasi-hyperbolic discounting are in principle problematic. I follow Bernheim and Rangel (2007) and O'Donoghue and Rabin (1999), and make welfare evaluations based on a "long-run" welfare criterion ($\beta = 1$).

To formalize the long-run perspective, I suppose there is a –fictitious– period 0 where the person has no decision to make and weights all future periods equally. The worker's long-run utility is:

$$u_0 = ln(c_1) + ln(c_2) + ln(c_3) \tag{4}$$

In the welfare analysis I compare long-run utilities of two different frequencies of payment: one upfront payment versus 3 payments. I calculate the long-run utilities under both schemes and show that paying every period dominates paying only once if β is sufficiently low, as illustrated in Figure A.3 (in Appendix), or the transaction costs (γ) are low enough (Figure A.4, in Appendix).

II.C. Model with Congestion Costs

I proceed by introducing congestion costs into the model. I assume that the representative consumer has quasilinear period utility function: it takes a logarithmic form with respect to the composite good (c_t) and it is linear with respect to the damage of congestion (z_t):

$$u_t = ln(c_t) - z_t \tag{5}$$

where $z_t = a\left(\int c_{it}\, di\right)^2$, and a is a small positive parameter that indicates the level of damage of total consumption accumulation at time t.[22]

It might be the case, for instance, that z_t represents the combined pollution and accident external costs of traffic congestion. Consumers need to travel in order to buy goods and services (c), and the higher the level of aggregate consumption at a specific moment of time, the higher will be the level of traffic congestion generated by people traveling to shopping. Congestion costs are generated in many other markets with capacity constraints and, under some assumptions, the mechanisms found in the model presented here can be extrapolated to what would happen in these other markets.[23] Hence, similar results would be found if we consider another sector with capacity constraints (cost adjustment of factors) and with cost of adjustment of prices (menu cost and information cost for the seller and

22. I use the simplifying assumption that this disutility is independent of the amount of the individual's own consumption. This is in line with many examples of congestion costs in the real world, and does not affect the qualitative results of the model.

23. Capacity constraint is an important feature of many markets (Lester, 2011). While in some markets time is the constraint (doctors can only serve a limited number of patients at once), in other markets space is an issue (restaurants have a limited number of tables), and also a seller's inventory could be occasionally a limiting factor (e.g. agents have a limited number of concert tickets available).

the consumer respectively). These adjustment costs enable firms to use price mechanisms to smooth the demand over the month without costs. In the case of traffic congestion, we can assume that the costs of adjusting the size of roads within a month is infinite and it is also too costly to continuously adjust pecuniary prices for using the roads.

Consumers optimize taking externalities as given (i.e. they consider that the level of congestion is fixed). For instance, the representative consumer ignores the costs of pollution and accidents generated from her own driving since these costs are borne by other agents. This free rider problem –each consumer thinks that her (car) consumption has very little impact on overall level of pollution– makes them treat the level of congestion as fixed and therefore it does not affect the agent's optimization.[24] The following are the utility functions that the consumer maximizes each period:

$$\begin{aligned} u_1 &= ln(c_1) - z_1 + \beta \left(ln(c_2) - z_2 + ln(c_3) - z_3\right) \qquad (6) \\ u_2 &= ln(c_2) - z_2 + \beta \left(ln(c_3) - z_3\right) \\ u_3 &= ln(c_3) - z_3 \end{aligned}$$

II.C.1. Equilibrium

The representative consumer maximizes her utility subject to her budget constraint. Because she takes z_t as given, it does not affect the agent's optimization, therefore the competitive equilibrium equals the consumption path presented in Subsection II.B. for the case without congestion costs.

24. Other assumptions of this model with traffic congestion and its external costs are: (a) there are no pecuniary prices paid by consumers for using the road; (b) capacity is fixed within the period –road capacity is fixed within a month and this is what generates congestion which leads to more time on the road and then higher pollution and traffic accidents–; (c) labor supply is fixed –it is difficult to change hours worked within a month–, then there is a fixed amount of time to be distributed between leisure, travel and shopping, and all these activities are equally valued by the agent.

II.C.2. Welfare Analysis

To compute welfare, I aggregate the consumption paths chosen for all consumers and again compare long-run utilities under both schemes of pay frequency. The representative agent takes the level of congestion as fixed and, as a result, she does not internalize the negative effect of increasing her own consumption on the utility of the rest of the agents.

Welfare analysis shows that when congestion costs are sufficiently high, paying more frequently (every period) dominates one upfront pay. Figure A.5 (see Appendix) displays, for the cases with and without congestion costs and under different levels of short-run impatience (β), the changes in consumer's welfare when frequency of wage payment is changed from one upfront payment to more frequent payments (payments in every period). In the presented parametrization –wage (w)=10; transaction cost (γ)=0.5 and congestion costs (a)=0.01–, because congestion costs are sufficiently high, paying every period dominates paying once for almost every level of short-run impatience (β). In contrast, for the same values of w and γ but if there were no existing congestion costs, paying every period would dominate one upfront payment only if $\beta \leq 0.65$. Figure A.6, in the Appendix, shows the relevance of congestion costs by presenting how total welfare changes when pay frequency increases, under different levels of disutility from congestion (a).

Summing up, in decision making the social planner faces several trade offs. On the one hand, by increasing the frequency of payments she increases the actual cost of the labor unit because total transaction costs increase. On the other hand, a consumer with quasi-hyperbolic discounting has a smoother consumption path under a more frequent payment scheme, then a higher frequency of pay directly increases her long-run utility and indirectly increases it by reducing congestion costs in sectors with capacity constraints. The model suggests that higher pay frequencies could be welfare improving if the level of short-run impatience of consumers is sufficiently high, transaction costs are low, and/or the costs of congestion are large.

An alternative policy to changing the pay frequency and that would also reduce the aggregate cycle, is to increase the number of paydays without changing the frequency of pay. It is straightforward that if the paydays are not the same for everybody and are evenly distributed among the period, the aggregation of cyclical individual expenditure would not generate aggregate cycles. Therefore, keeping fixed the pay frequency but paying workers on different dates would reduce the congestion costs by smoothing aggregate activity without increasing transactions costs. If individuals do not receive their paychecks on the same dates, some coordination failures could arise if workers enjoy spending money together. In such a case, the social planner should have to trade-off between the welfare gains from reducing congestion versus the losses generated by being unable to coordinate the time of expenditure.

II.D. From the Model to the Data

The main prediction of the model is that a higher frequency of wage payments may lead to a smoother pattern of household expenditure, which would also translate into a smoother path of aggregate economic activity within the month. In the empirical analysis I test whether pay frequency actually affects the patterns of household expenditure and aggregate activity. I analyze whether the effects are more pronounced in houses with likely higher self-control problems, and whether low pay frequencies are generating cycles in the activity of sectors where congestion is a relevant issue.

To empirically study the impact of payment frequency on within-month patterns of household expenditure and aggregate economic activity, I take advantage of two different sources of exogenous variations in the frequency of payments in the United States. First, I exploit a between household variation in pay frequency that allows me to identify its effects at household level. More precisely, I compare the pattern of expenditure of *retired couples* (households with both spouses retired) who, by chance, every month receive all their Social Security income on one day to the pattern observed for couples with two paydays (Section III.). Second, I exploit

US state variation in the legislation of the frequency of wage payments, which allows me to identify aggregate effects of pay frequency (Section IV.). Finally, I use exogenous variations in the dispersion of paydays over the month drawn from the same natural experiments, in order to show that even under a low frequency of pay the within-month cycles in economic activity can disappear if paydays are evenly spread over the month (Section V.).

III. Pay Frequency and Expenditure Patterns: Household Level Evidence

This section compares the within-month expenditure patterns of households that, by chance, have different pay frequencies, and shows that more frequent payments lead to smoother patterns of household expenditure.

III.A. Social Security Payments in the United States

Around 54 million people receive Social Security benefits in the US. The earliest retirement age is 62, with reduced benefits, while full retirement benefits can be obtained at 65.[25] Social Security benefits are paid over the month according to the following rule: individuals retired before May 1997 are paid on the 3rd of the month, and individuals who become eligible for Social Security benefits after May 1997 are paid on either the 2nd, the 3rd or the 4th Wednesday of each month, depending on their date of birth.[26] More precisely, individuals born between the 1st and the 10th day of the month are paid on the 2nd Wednesday of each month; those born between the 11th and the 20th day of the month, are paid on the 3rd Wednesday; and those born between the 21st and the 31st day of the month, are paid on the 4th Wednesday.

As a result, couples of pensioners who retired after 1997 can have one or

25. For individuals born after 1942, full retirement benefits can be obtained at 66.

26. This payment scheme implies that nowadays, individuals paid the 3rd of the month are probably those born before 1932 (age$\geqq$65 in 1997), and the new system certainly applies to people born in or after 1936 (age<62 in 1997).

two paydays every month, depending on spouses' birthdays. For instance, those households with both spouses born on dates such that they receive their paychecks on the same Wednesday – e.g., husband's birthday is April 13th and wife's birthday is October 18th –, have only one payday per month, while households where spouses are paid on different Wednesdays – e.g., husband's birthday is April 13th and wife's birthday is October 28th –, have two paydays every month (Table I).

III.B. Data: Consumer Expenditure Survey

In this section I use the Consumer Expenditure Survey (CEX), which provides information on a household's daily expenditure. The CEX is conducted in two parts: a quarterly interview and a diary survey. Each household is chosen for only one of these two surveys.[27] I use data from the diary survey, where respondents are asked to keep two one-week diaries (a total of 14 days) for recording all purchases made each day.[28]

The dataset contains the demographic information of each household member. It does not include information about paydays; however, as explained in Section III.A., I can infer the payday of retirees from their birthdays and thus derive the number of paydays per month in each retired couple.[29]

I analyze households with both spouses receiving Social Security payments. More precisely, the sample just includes couples with both spouses retired after 1997, because only individuals retired after that year have paydates of Social Security benefits that depend on birthdays, then for these couples the assignment of the number of paydays is *as-good-as-random*. The dataset covers the period 1998-2008. It does not include information for previous years because paydates start depending on birthdays after 1997, and it does not include data from more recent years because after 2008 the BLS stopped asking interviewees to report

27. Each address is representative of around 15,000 other households in the US.

28. The starting date of the diary survey for any household is randomly selected.

29. Information about birthdays is not publicly available in the CEX, and it was kindly provided by the U.S. Bureau of Labor Statistics (BLS). More specifically, the BLS gave me access to a variable indicating whether an individual's birthday is within the first 10 days of a month (1st-10th), the second 10 days of a month (11th-20th) or the last days of a month (21st-31st).

their exact date of birth.

Table II shows the summary statistics of socio-demographic characteristics of the sample of interest. As expected, demographic characteristics of households with one and those with two paydays per month are not significantly different. The mean age of husbands in the sample is 67.5, and wive's mean age is 65.9. These households have an annual income of $38,323 on average, with around $18,731 coming from Social Security benefits.[30] Most of these couples live alone (the mean family size is 2.15), therefore the mean number of earners –i.e. people working for pay– in the households is almost negligible (0.06).

Expenditure Categories. Following Stephens (2003), I analyze expenditure on goods likely to be consumed relatively soon after they are purchased, with a main focus on food. I classify expenditure in several categories: expenditure on nondurables (expending on food and alcohol, tobacco related items, personal care items, public transportation, gas, and motor oil); food and alcohol, distinguishing between those items consumed at home and those consumed away; fresh food; and instant consumption (food and alcohol consumed away from the household, participant sports and lessons, entertainment activities and sporting events, among others).[31]

Table III shows the summary statistics of daily expenditure of households under analysis. An interesting result is that average daily expenditure in every category analyzed is not significantly different between households with different pay frequencies (with the only exception of food consumed away from home with a significant difference at 10%). Thus, even though pay frequency could affect the timing of expenditure it does not impact the amount of money households expend over the month. Thus, this result suggests that pay frequency does not affect household's savings.

Every day these households expend, on average, $130.5. On nondurables, their average expenditure is $22.7; on food and alcohol consumed at home they expend

30. The variable representing the income from Social Security benefits has 25% of missing values.

31. All expenditure data are deflated with the CPI into 2000 dollars.

around \$16.1 per day, with \$10.3 expended on food and alcohol consumed at home (\$1.74 on fresh food), and \$5.8 on food and alcohol consumed away from home. The mean of daily expenditure on the category of instant consumption is \$7.6.

III.C. Empirical Strategy

To test whether pay frequency matters for expenditure smoothing, I analyze the daily expenditure of retired couples with paydates depending on spouses' birthdays. The underlying idea of the identification strategy is to compare the patterns of expenditure of households that, by chance, have only one payment per month (i.e. both spouses were born in dates such that they receive their paychecks on the same Wednesday) and households with two paydays every month (i.e. both spouses are paid on different Wednesdays).

The main specification to test whether the frequency of payment matters for the expenditure patterns of retired couples, is the following:

$$\begin{gathered} C^x_{i,t} = \beta_0(One\,Paycheck\,this\,Week)_{i,t} + \beta_1(Two\,Paychecks\,this\,Week)_{i,t} + \alpha_i + \\ \sum_{k=2}^{7}\gamma_k DOW_k + \sum_{s=2}^{14}\tau_s DOS_s + \sum_{m=2}^{12}\phi_m Month_m + \sum_{w=2}^{5}\lambda_w WOM_w + holiday_t + \epsilon_{i,t}, \end{gathered} \tag{7}$$

where $C^x_{i,t}$ is household i's expenditure on category x at day t; α_i is a household fixed effect; DOW_k are day of the week fixed effects; DOS_s is a dummy variable equal to one if it is the sth day of (consumer unit i's) survey; $Month_m$ are month fixed effects; WOM_m are week of the month fixed effects (1st week for the first 7 days of the month, 2nd for the 8th to 14th, etc.), and $holiday$ is an indicator variable for holidays.[32] Variable $One\,Paycheck\,this\,Week$ equals 1 if one and only one spouse received a paycheck between 0 and 6 days before day t, and it is 0 otherwise. $Two\,Paychecks\,this\,Week$ is a dummy variable that equals 1 if both spouses received their paychecks between 0 and 6 days before day t.

32. The variation in the timing of pay (2nd, 3rd or 4th Wednesday), allows me to control for week of the month fixed effects. In previous literature it was difficult to control for the week of the month because in other institutional frameworks there was not enough variation in pay days (for instance, under the Social Security payment structure analyzed in Stephens (2003), every pensioner received their payment on the 3rd of the month).

The parameters of interest are β_0 and β_1, and they allow us to estimate whether expenditure on any given diary day depend upon whether they fall within the first week after the check's arrival or not, for the case in which spouses are paid on different weeks and the case in which both received their paychecks on the same day, respectively.

As explained in Section III.A., the assigned payday of Social Security benefits depends on the beneficiary's birthday. Before starting with the main analysis, I show in Table IV that this assignment is as-good-as-random. As expected, day of birth is not correlated with any observable individual characteristic. Panel (A) of Table IV presents the estimation results of the following specification:

$$\begin{aligned} X_i = \alpha + \beta_1(Husband\, born\, 11 - 20th)_i + \beta_2(Husband\, born\, 21 - 31st)_i + \\ \beta_3(Wife\, born\, 11 - 20th)_i + \beta_4(Wife\, born\, 21 - 31st)_i + \epsilon_i \end{aligned} \tag{8}$$

where X_i is any of these household characteristics: age of husband, age of wife, household income or household income from Social Security benefits.

In Panel (B), I present the results of regressing any of these household characteristics against a variable indicating whether it is a household with only one payday – i.e. both paychecks arrive on the same Wednesday every month. Again, there is no significant relationship between household characteristics and the pay frequency assigned to the household.

III.D. Results

Table V shows the results of estimating equation (7) by OLS. The estimated coefficients presented in this table indicate, for different categories of expenditure, the difference of daily expenditure within 0-6 days since a check's arrival relative to daily expenditure during weeks without paycheck receipt. Results show two important findings: not all households smooth expenditure between paychecks, and this effect depends on the frequency of payments. While those households with two paydays seem to be able to smooth their expenditure throughout the month (the estimated coefficient of variable *"One Paycheck this Week"* is not statistically significant for any category of expenditure), households with only one payday every month expend more on the weeks they receive their payments than on weeks they do not (see estimated coefficients of *"Two Paychecks this Week"*). For this last group of households, total daily expenditure and daily expenditure in nondurables increase by 34 dollars and 3.9 dollars respectively during the week of payment, although the coefficients are not statistically significant. Over the week of payment daily expenditure on food significantly increases by 4.8 dollars, food at home is 3 dollars higher on those days, and food away from home increases by 1.8 dollars, while expenditure on fresh food does not change on that particular week. Instant consumption is higher during the first week after payday (0.8 dollars higher), however the coefficient is estimated imprecisely.[33,34]

III.D.1. Heterogeneous Effects by Household Income

The impact of pay frequency on expenditure patterns may be heterogeneous by household income. For instance, one implication of the model presented in Section II. is that we could expect a more pronounced impact of pay frequency in expenditure patterns of poorer houses because these households are more likely to be credit constrained, plus poor people may have higher short-term discount rates (Mani et al., 2013).[35]

33. The sample analyzed here only includes households in which both spouses started receiving Social Security payments after 1997. Individuals retired before 1997 are all paid the 3rd of the month, then the inclusion of these – older – individuals in the sample would make weaker the assumption that the assignment of the number of paydays is *as-good-as-random*. For instance, a couple with an "old retiree" (retired before May 1997) and a "young retiree" (retired after 1997) will have no chance of having only one payday, because both will always be paid on different weeks of the month (i.e. the eldest gets the paycheck on the 3rd and the other one on the 2nd, 3rd or 4th Wednesday depending on her birthday). Thus, if we include these couples in the analysis we should expect that the pay frequency would be associated with certain types of couples, which could bias the results (e.g. young couples, i.e. both spouses retired after 1997, would be more likely to have only one payday than mixed couples, i.e. those with one individual retired after 1997 and the other retired before; while old couples, i.e. both spouses retired before 1997, will be more likely to have only one payday than the rest of couples because both spouses would be paid the 3rd of the month). Nevertheless, this bias seems to be not too important because results presented in this section are robust to the inclusion of couples in which one spouse started receiving Social Security benefits before 1997 (results available upon request).

34. Results are robust to not imputing with zeros the expenditure on days without information in the CEX survey diary (Tables in Appendix, Section C., show these results).

35. Mani et al. (2013) argue that the human cognitive system has limited capacity, and they show that scarcity further reduces these cognitive resources, such as self-control, which hampers

I test whether the effects of pay frequency are more important in poorer households by running equation (7) for couples with different levels of income, for which I break down the income distribution into quartiles. Results, presented in Table VI, show that for all income groups the estimated coefficient of the variable *"One Paycheck this Week"* (β_0) is not statistically significant for any category of expenditure. However, several point estimates of the coefficients of *"Two Paychecks this Week"* (β_1) are significantly different from zero in the sample of households in the lowest income quartile, and for those cases β_1 is also significantly different from β_0 (see the F-tests for differences in coefficients provided in Table VI). This means that poorer households with only one payday per month expend significantly more in the weeks they receive their payments than in weeks they do not, while it does not happen if the paychecks are spread over the month. During weeks of payments, the poorer households of the sample significantly increase their daily expenditure in nondurables by 6.6 dollars; food and alcohol expenditure increases by 7 dollars, of which 5.7 dollars come from higher expenditure on food consumed at home; and daily fresh expenditure on fresh food is 1.1 dollars higher on weeks of paycheck receipt (pay-week). Instant consumption and food away from home are higher during the pay-week, however these coefficients are estimated imprecisely.

Notice the link of these results to the model discussed in Section II.. As predicted by the model, lower pay frequencies lead to cycles in the within-month pattern of household expenditure. Moreover, during pay weeks poor households spend significantly more on fresh food (+56%), an item that is consumed very soon after purchase. This suggests that not only expenditure, but also consumption of some items are affected by the frequency of pay of these households. Finally, the impact of low pay frequencies is large and statistically significant only if household income is sufficiently low, i.e. the effect is relevant for households that are more

the ability of poor people to make time consistent decisions. The idea is that preoccupations with pressing budgetary concerns leave fewer cognitive resources available to guide choice and action. For poor households scarcity of money creates a focus on pressing expenses today, and then attention goes to the benefits of expending more now and not to its costs, i.e. having less to spend on the succeeding weeks.

likely to be credit constrained and to have higher short-term discount rates, as the model highlights.

III.D.2. A Test of Income Pooling

In the previous exercises households are viewed as unitary households, i.e. each household is assumed to act as if spouses maximize a single utility function, at least when they have to decide about how much to expend each day in the set of goods and services analyzed in this paper. If we assume that husbands and wives pool their income when deciding about this expenditure, which spouse receives the paycheck on a given week (husband or wife) should not affect expenditure decisions. Thus, the underlying assumption in the previous analysis is that for choice outcomes it is the frequency at which the household receives its income that could matter, and not the timing of pay of each spouse.

I present two exercises to reflect that income pooling is a plausible assumption for the cases analyzed in this paper. First, for the outcomes of interest I estimate equation (9), which adds to equation (7) an interaction between receiving $One\,Paycheck\,this\,Week$ and a dummy variable indicating the gender of the recipient, more precisely whether it was the husband paid that week.

$$\begin{gathered}C^x_{i,t} = \beta_0(One\ Paycheck\ this\ Week)_{i,t} + \beta_1(Two\,Paychecks\,this\,Week)_{i,t}+ \\ \beta_2(One\ Paycheck\ this\ Week * Husband's\ Paycheck)_{i,t} + \alpha_i + \textstyle\sum_{k=2}^{7}\gamma_k DOW_k+ \\ +\textstyle\sum_{s=2}^{14}\tau_s DOS_s + \sum_{m=2}^{12}\phi_m Month_m + \sum_{w=2}^{5}\lambda_w WOM_w + holiday_t + \epsilon_{i,t},\end{gathered} \tag{9}$$

Estimated coefficients of $OnePaycheckthisWeek$ and $TwoPaychecksthisWeek$ still indicate the difference of daily expenditure within 0-6 days since a check's arrival relative to daily expenditure during weeks without paycheck receipt, with the only difference that the coefficient of $One\,Paycheck\,this\,Week$ represents this effect for the case when the only one receiving a paycheck is the wife. The coefficient of the interaction $One\ Paycheck\ this\ Week * Husband's\ Paycheck$ would represent the difference in choice outcomes that could emerge if it was not the wife but the husband receiving the paycheck that week. This interaction would help us to test whether the gender of the recipient makes any difference in the choice outcomes, a fact that would go against the assumption of income pooling. I focus the analysis on the sample of low income households, for which we have seen that the effect of pay frequency is more significant, however results are robust to analyze the whole sample of households (See Table C.4 in Appendix, Section C.). Results are presented in columns 1-7 of Table VII, and show that for the sample of households in which spouses are paid in different weeks, expenditure during a week of pay is not different to expenditure during a week without paycheck receipt, independently of whether the husband or the wife received the paycheck in that week, i.e. the coefficients of $One\,Paycheck\,this\,Week$ and the interaction of interest are not significantly different from zero.[36]

Second, I estimate equation (9) using as outcome variable daily expenditure on an *assignable good*. An assignable expenditure is such that could be allocated only to the husband or the wife, because of its exclusive consumption. I use the most popular candidate for an assignable good: clothing (Bourguignon et al., 2009).[37] If wives have a greater interest in women's clothing than do husbands, an increase in women's clothing expenditure relative to men's clothing expenditure after wives get their paychecks would go against our assumption of income pooling. Results shown in Table VII cannot reject income pooling for this set of assignable goods. Again, the frequency of payment matters for smoothing expenditure (columns 8-10 of Table VII): expenditure on clothing increases during weeks of pay in low income households with only one paydate (i.e. coefficient of variable $Two\,Paychecks\,this\,Week$ is significantly different from zero), but this does not happen in households paid more frequently, independently of whether the husband or the wife is the one receiving the paycheck (i.e. coefficients of $One\,Paycheck\,this\,Week$ and the interaction of interest are not significantly different from zero).

Whether spouses pool their income or not is not easy to test empirically. Pa-

36. Same results are found if in the sample we only include households where both spouses are paid on different days. Results are not shown here but are available upon request.

37. In the case of clothing, households answering the interview of the CEX should report whether the cloth they bought was for a female or a male.

pers analyzing whether families pool their resources when making consumption decisions usually use an exogenous change in the intra-household distribution of income in order to test income pooling (Lundberg et al., 1997, Hotchkiss, 2005, Ward-Batts, 2008 and Duflo and Udry, 2004). Here I have proposed a novel identification strategy to carry out this test, which instead of exploiting variations in the (permanent) intra-household distribution of income takes advantage of variations in the timing at which spouses receive their paychecks. Although the test is not perfect, it is useful to better understand what is going on within the set of couples analyzed in this paper. Using this test I could not reject the income pooling hypothesis, which leads me to be confident about the assumption that these households pool their income –at least when deciding about the outcomes of interest in this paper–, and so to the conclusion that low frequencies of income payments generate within-month cycles in household expenditure, specially in poor households.

IV. Pay Frequency and Aggregate Activity: State Level Evidence

Now I proceed to analyze the impact of pay frequency on the patterns of aggregate economic activity. In the previous exercise I studied pay frequency's effects at household level by analyzing the behavior of retired couples. Because these households are not representative of the whole US population receiving periodic payments, can we extrapolate these results to the rest of the society to gain knowledge about the impact of pay frequency at aggregate levels? I now exploit a variation in wage pay frequency, which allows me to complement the previous exercise in different ways. First, by analyzing the effects of paying workers at different frequencies I can infer whether the impact I estimated for the sample of retired households are consistent with those we would find in the case of analyzing workers. Second, and more important, this exercise allows me to identify the effects of pay frequency at aggregate level, focusing in particular on sectors where congestion is an important issue. More precisely, I analyze the impact of wage pay frequency on the pattern of activity indicators linked to sectors with significant capacity constraints – i.e. time spent shopping, levels of air pollution and number of traffic accidents are associated with activity in groceries, traffic on roads, hospitals, among other markets where congestion externalities matter.

IV.A. State Laws Regulating Wage Payment Frequency in the United States

US states laws requiring the payment of wages at specified times were first enacted at the end of the 19th century and in the first decades of the 20th century.[38] By around 1940, nearly all states had enacted this sort of legislation, requiring the payment of wages with a specified periodicity: weekly, biweekly, semi-monthly or monthly. At that moment, the majority of the States specified that wages should be paid at least semi-monthly (Monthly Labor Review, 1938), with the exception of New England states which require that wages should be paid weekly (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut).

Prior to these laws, the custom was to pay workers monthly. According to Paterson (1917), the laws requiring wage payment to the employee at certain regular intervals were enacted with the objective of "protecting the workman against the hardships resulting from payment at long intervals and the temptations which inevitably accompany buying on credit. [...] The employer has always [...] sought to make the periods of payments at long intervals" (Paterson, 1917).

The demand for weekly payment was first made in around 1875 in Massachusetts. In 1879, a law was passed stating that "cities shall, at intervals not exceeding seven days, pay all laborers who are employed by them [...] if such

38. In the 19th century laws of this kind were also enacted in many European countries (Switzerland: Federal Law, Mar. 23, 1877, pay at least once every 15 days; Belgium, Act, Aug. 10, 1887, pay at least twice a month; Russia, Law, Mar. 14-20, 1894, wages must be paid at least once a month, and at least twice a month if the duration of the contract is not determined; France passed a bill in 1894 which required that the wages of employees should be paid at least twice a month, the greatest interval allowable to be 16 days; Austria (1898) and Norway (1892) declare laws with the principle that the payment take place each week).

payment is demanded."[39] Seven years later the law was extended to include all workers and a penalty for violation of the act. Connecticut was the first State to follow the example set by Massachusetts. A law passed in 1886 provided that laborers be paid weekly. One year after, New Hampshire required the payment of wages earned each week within eight days after the expiration of the week. The New York Legislature in 1890 passed a general labor law requiring weekly payment. In 1891 in Rhode Island a general weekly payment act was passed. The Indiana Legislature provided in 1891 for the weekly payment of wages to within six days of pay day. The Vermont Legislature passed a law in 1906 which required corporations engaged in certain enumerated classes of business to pay their employees each week. At the end of the 19th century, most of the remaining States adopted laws for semi-monthly or biweekly payment of wages,[40] while Indiana (1889), Colorado (1895), Maryland (1888), Missouri (1889), Virginia (1887) and Mississippi (1912) enacted laws requiring monthly payments.

The laws regulating the frequency of wage payments remain active today. The majority of states have statutes requiring that –at least certain– employees receive their wages periodically. Employers may pay employees earlier or more frequently than the minimum periods mandated by state laws, but not later or less frequently unless the law allows such an exception. Almost all of these laws include penalties for violation, subjecting the employer to criminal punishment and/or to a fine.

The most common requirement is semi-monthly payments, while some states

39. When the newly-elected governor of Massachusetts, George D. Robinson (1884 – 1887) gave his inaugural address he made the following recommendation to the assembled members of the Legislature: "Why not leave this [regulation of the frequency of payment] to the will of the contracting parties? It has been left there, and the evils and hardships are before us. It is, I submit, always wise and salutary to devise legislation of such a character as will reach the humblest and the poorest citizen, who has no voice but his own to present his needs, – no power in combination with others to emphasize his opinions. [...] Would it not be better for the laborer at mere living wages to have his pay weekly? The advantages are plain. Greater independence of action would result; the cash system would prevail, to the benefit of the seller as well as the buyer; exposure to the vexation and costs of collection suits would be substantially removed, and the lesson of economy be practically taught every day".

40. Maine (1987), Pennsylvania (1887), Ohio (1890), Missouri (1889), Iowa (1894), Maryland (1896), Kentucky (1898), Arkansas (1909), Tennessee (1913), Virginia (1887), West Virginia (1887), Wisconsin (1889), Wyoming (1890-91), New Jersey (1896), Arizona (1901), Hawaii (1903), Oklahoma (1909), Illinois (1913), Michigan (1913), South Carolina (1914), California (1915), Kansas (1915), Minnesota (1915,), North Carolina (1915), Texas (1915) and Louisiana (1912) (Paterson, 1917 and Redmount et al., 2012).

require weekly, biweekly or monthly payments.[41] In 2008, seven states required weekly payments, while semi-monthly payments were required in 19 states and in Washington DC.[42] The remaining states required biweekly payments (three), monthly payments (ten), or they left open the option of paying salaries weekly, biweekly or semi-monthly (four). Finally, there were seven states without specified regulations regarding the frequency of pay.[43]

IV.B. Data on Aggregate Economic Activity

I exploit data from several sources to compare the within-month patterns of aggregate economic activity in states in which the frequency with which wages are paid differs by law. More precisely, I use measures of time spent shopping, traffic accidents and air pollution to proxy for economic activity.[44]

While time spent shopping can be directly linked to an increase in sales, the relationship between economic activity and air pollution or vehicle crashes may be not as straightforward. However, recent research provides evidence that CO2 emissions and GDP move together over the business cycle. Doda (2014) shows that emissions tend to be above their trend during booms and below it during recessions. Heutel (2012) and Heutel and Ruhm (2013) show the same evidence for the United States. There is also a large literature studying the positive correlation between mortality and economic activity, and the evidence shows that motor vehi-

41. U.S. Department of Labor, Wage and Hour Division (WHD). http://www.dol.gov/whd/state/payday2008.htm

42. In some of these states, the weekly or semi-monthly requirement does not hold for all occupations.

43. Weekly payments: Connecticut, New Hampshire, Rhode Island, Vermont, Massachusetts, Michigan and New York. Semi-monthly payments: Arizona, Arkansas, California, District of Columbia, Georgia, Hawaii, Illinois, Kentucky, Maine, Missouri, Nevada, New Jersey, New Mexico, Ohio, Oklahoma, Tennessee, Utah, Wyoming, Alaska and Texas. Biweekly: Indiana, Maryland and West Virginia. Monthly payments: Colorado, Delaware, Idaho, Kansas, Minnesota, North Dakota, Oregon, South Dakota, Washington and Wisconsin. States without specified regulations regarding the frequency of pay: Alabama, Pennsylvania, North Carolina, Nebraska, South Carolina, Florida and Montana. The states that propose more than one pay cycle indistinctly are Iowa, Louisiana, Mississippi and Virginia.

44. For this analysis, the data from the Consumer Expenditure Survey (CEX) cannot be used because the samples for the CEX are national probability samples of households designed to be representative of the total U. S. civilian population, and are not designed to produce state-level estimates (U.S. Department of Labor, 2009).

cle accidents account for the bulk of the cyclicality in mortality. Ruhm (2000) and Miller et al. (2009) find that a one-point increase in unemployment is predicted to reduce traffic deaths by between two and three percent. These are thought to be the result of individuals driving fewer miles when economic activity decreases. Papers analyzing the effect of the paycheck on mortality also suggest that this relationship can be driven by an increase in economic activity that increases motor vehicle fatalities (Evans and Moore, 2011, Evans and Moore, 2012 and Andersson et al., 2015). Evans and Moore (2011) point out that "receiving a pay check may, for example, encourage people to go out that day, which by construction increases activity and exposes the consumer to the hazards of driving in traffic".

These three indicators are particularly relevant for this paper because there is daily-state data for all of them, and because of their links to markets with congestion problems. As I discuss in Section II., within-month cycles are important in sectors with capacity constraints (restaurants, groceries, roads, hospitals, etc), because the spikes in activity generate congestion costs.

IV.B.1. Time Spent Shopping and Traveling

The data about time spent shopping comes from the American Time Use Survey (ATUS).[45] This survey collects information on all activities carried out by individuals during a designated 24-hour period. The ATUS was first administered in 2003 and has continued throughout each year since, then this analysis covers the 2003–2013.

Each ATUS respondent is asked to provide detailed information on his/her activities during a designated 24-hour period. Time spent obtaining goods and services includes all time spent acquiring any goods or services (excluding medical care, education, and restaurant meals). It includes grocery shopping, shopping for other household items, comparison shopping, coupon clipping, going to the bank, going to a barber, going to the post office, and buying goods on-line. Travel related to purchasing goods and services includes travel related to consumer purchases, to

45. I extracted the data from the IPUMS Time Use webpage using the ATUS Extract Builder database (http://www.atusdata.org, Hofferth et al., 2013).

using professional and personal care services, to using household services, to using government services, and to participation in civic obligations. Summary statistics are presented in Panel (A) of Table IX.

IV.B.2. Fatal Accidents

To analyze the pattern of traffic accidents, I use data from the Fatality Analysis Reporting System (FARS) for the period 2000-2013.[46] This dataset contains information on all vehicle crashes in the United States that occur on a public roadway and involve a fatality. The sample has data for crashes in 3520 cities. I sum up all fatal accidents at the level of state-date and analyze the number of crashes and the number of fatalities. Panel (B) of Table IX shows the summary statistics of fatal accidents in the sample of states analyzed.

IV.B.3. Air Pollution

There are six primary air pollutants to measure air quality: ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter (PM), and lead. As in Currie et al. (2009), Heutel and Ruhm (2013) and Knittel et al. (2015), I focus on carbon monoxide (CO), ozone (O3) and particulate matter less than 10 microns in diameter (PM10), because these three pollutants are most commonly tracked by air quality monitors (Currie et al., 2009).

Carbon Monoxide (CO) is a gas resulting from the incomplete combustion of hydrocarbon fuels. Motor vehicles contribute over 80 percent of the CO emitted in urban areas. Ozone is created when oxides of nitrogen (NOx) and volatile organic compounds (VOCs) react in the presence of sunlight and it is a major component of smog. Particulate Matter (PM10) are small particles made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles, which are suspended or carried in the air and have an aerodynamic diameter less than or equal to 10 microns (about 1/7 the diameter of a single human hair).

46. http://www.nhtsa.gov/FARS

I use data from the Air Quality System (AQS) database.[47] This dataset contains daily air pollution concentration data from monitors in cities of the 50 states of the United States and the District of Columbia.[48] The sample covers the period 2000-2013. Panel (C) of Table IX shows the summary statistics of the sample of interest.

IV.C. Empirical Strategy

I focus the study on the states requiring weekly or semi-monthly payments (Figure A.7 in the Appendix highlights, in a map of the US, the states analyzed in this section). States requiring monthly payments are not in the sample because there the rate of compliance is very low, and wages are usually paid more frequently (only 6% of workers are paid monthly in these states). States requiring biweekly payments cannot be included because when exploiting the variation in state laws I analyze aggregate data, and for the identification strategy used I need to be able to infer the usual week of pay of workers, which is possible if the periodicity is weekly or semi-monthly but not if payments are made every two weeks. More specifically, while weekly payments are paid every week and semi-monthly payments are normally made the 1st and the 15th of each month, under biweekly paychecks workers of a state are not necessarily paid on the same weeks, e.g. some workers can be paid on the 1st and the 3rd week, while others on the 2nd and the 4th week.[49]

In the analysis of within-month economic activity at the state level, I run the following regression using as outcome variables measures of (1) time spent shopping, (2) air pollution or (3) traffic accidents:

47. http://aqsdr1.epa.gov/aqsweb/aqstmp/airdata/download_files.html#Daily
48. http://www.epa.gov/airdata/ad_glossary.html
49. Under semi-monthly payments, if the 15th is not a weekday, wages are usually paid the Friday before. In some cases, the other salary is paid on the last weekday of the month instead of the 1st.

$$
\begin{aligned}
Y^j_{s,t} = \beta_{-2}Week_{-2} + \beta_0 Week_0 + \beta_1 Week_1 + \alpha_s + & \\
\textstyle\sum_{k=2}^{7} \gamma_k DOW_k + \sum_{m=2}^{12} \phi_m Month_m + & \qquad j = \{weekly, semi-monthly\} \\
\textstyle\sum_{l=2001}^{2013} \delta_l Year_l + holiday_t + \epsilon_{i,t}, &
\end{aligned} \tag{10}
$$

where $Y^j_{s,t}$ is the measure of activity at day t in state s requiring semi-monthly payments or weekly payments (j identifies the type of the state, and regressions are run separately for states with laws requiring weekly payments and states requiring semi-monthly payments); α_s is a state fixed effect; DOW_k are day of the week fixed effects; $Year_l$ and $Month_m$ are year and month fixed effects; and $holiday$ is an indicator variable for holidays. $Week_{-2}$ equals 1 if the observation is between 14 and 8 days before the 15th (or the previous Friday if the 15th is not a weekday) – i.e. 2 weeks before –, $Week_0$ equals 1 if the observation is between 0 and 6 days from the 15th, and $Week_1$ equals 1 if it is between 7 and 13 days from the 15th – i.e. one week after –. In this case, β_{-2}, β_0 and β_1 are the parameters of interest.

As air pollution is measured at city level, the analysis that considers air pollution as outcome variable includes city fixed effect instead of state fixed effects. When I analyze time use data I also control for (X_i) individual characteristics (sex, age, race, marital status, working status, and family income).

IV.D. Results: Pay Frequency and Within-month Trends in Activity

Time use. Table X reports results of the regression specified in equation (10), where the outcome variables are total time spent acquiring any goods or services (columns 1 and 3), and time spent on travel related to purchasing goods and services (columns 2 and 4). The first two columns of this table show the results for the sample of states requiring weekly payments, and the last two columns present the results for the sample of states requiring semi-monthly payments. Estimation results show that in states requiring weekly payments there is no significant difference over the month in time spent doing shopping, nor on travel related to shopping. However, in states with semi-monthly payments people spent significantly more time in these activities during the weeks of pay, i.e. the first week of the month and the week of the 15th.[50]

Traffic accidents. A similar effect of pay frequency is found in the evolution of traffic accidents throughout the month. Table XI shows the results of running specification (10) for the cases in which the right-hand side variables are the daily amount of traffic accidents and number of fatalities in these accidents. Again, results shown in columns 1 and 2 correspond to the sample of states with legislation requiring weekly payments, and columns 3 and 4 show the results for the sample of states requiring semi-monthly payments. In both sets of states there is a first of the month effect on the number of traffic accidents, in line with the results of Evans and Moore (2011), although the first week of the month effect is not significant for traffic-related deaths. It is important to highlight that this first of the month effect is significantly stronger in the sample of states requiring semi-monthly payments. Moreover, in states with weekly payments the patterns of crashes and related deaths are not significantly different over the rest of the month, but in states with semi-monthly payments there is another significant increase in the number of fatal accidents and related deaths during the week of the 15th, the moment when workers of these states usually receive the second payment in the month.

Air pollution. Table XII reports the results of the regression specified in equation (10), in this case using as outcome variables two different measures of air pollution: Carbon monoxide (CO) and particulate matter less than 10 microns in diameter (PM10). Again, the within-month trends are different in the sample of states requiring weekly payments (first two columns) and the sample of states requiring semi-monthly payments (last two columns). On the one hand, in states requiring weekly payments the level of PM10 does not seem to be significantly different over the month, and the levels of CO decrease at the end of the month. On the other hand, in the set of states requiring semi-monthly payments, there

50. All results in this subsection are robust to using Cameron et al., 2011 two-way clustering method for standard errors, allowing for both state and time dependence in the errors. However, since the number of states is small, the two-way clustering estimator may perform poorly in this case (Villacorta, 2015).

is a significant increase in the levels of CO and PM10 during the two weeks of semi-monthly payments (the first week of the month and the week of the 15th). As a robustness check I analyze the evolution within the month of levels of ozone, the other pollutant frequently used in the economics literature. Because ozone is known for being uncorrelated with economic activity (Graff Zivin and Neidell, 2012, Knittel et al., 2015), we expect to find no effect of pay frequency on the within-month pattern of this pollutant.[51] Results of this robustness check are presented in Table C.5 (Appendix, Section C.), and show that in the case of ozone its levels are uncorrelated to the timing of pay in states paying semi-monthly. More precisely, in both groups of states there is no significant pattern of ozone levels over the month, i.e. all coefficients of interest are not significantly different from zero in states paying weekly and in states paying semi-monthly.

Summing up, results show that the pattern of economic activity within the month is associated with the frequency of the payment of wages. More specifically, the evidence suggests that higher pay frequencies lead to smoother aggregate economic activity over the month, which is consistent with the results previously found at household level and the model presented in Section II.. The cycles in time spent shopping, traffic accidents and air pollution are associated with cycles in the activity of groceries, roads, hospitals, among other sectors with capacity constraints, where spikes in activity generate important congestion costs. As discussed in Section II., these congestion externalities could lead to market equilibria with suboptimally low pay frequencies.

51. As Graff Zivin and Neidell (2012) discuss in their paper "aggregate variation in environmental conditions is largely driven by economic activity, except for daily variation in ozone which is likely to be exogenous. Ozone is not directly emitted but forms from complex interactions between nitrogen oxides (NOx) and volatile organic chemicals (VOCs), both of which are directly emitted, in the presence of heat and sunlight."

V. Timing of Pay and Aggregate Activity

This section takes advantage of the fact that the natural experiments analyzed before not only allow for variation in the frequency of payments but also provide variation in how concentrated are the paydays over the month. I exploit such variation in the timing of payments in order to analyze whether evenly spread paydays over the month helps to smooth economic activity, even in contexts of infrequent payments.

I start by analyzing the sample of retired couples to study how their aggregate expenditure behaves over the month depending on whether everybody gets the paycheck on the same date or not. Results presented in Section IV. showed that a low pay frequency scheme (both spouses receiving the paychecks on the same day) leads to cyclical household expenditure. In this section I focus on those retired couples with one payday and test if, even under low pay frequencies, their aggregate expenditure could be smooth whenever the paydays are evenly spread over the month. Focusing on the sample of retired couples with one payday a month allows us to disentangle pay frequency effects from the effects of the timing of payments.

Under this setting, I exploit the following variation in the the timing of pay: individuals retired before 1997 receive their paychecks on the 3rd of the month while Social Security benefits of individuals retired after 1997 are paid on either the 2nd, the 3rd or the 4th Wednesday the month. For couples with both spouses receiving the checks on the same day, I analyze the evolution of their aggregate expenditure over the month using the following empirical specification:

$$\begin{aligned} C^x_{i,t} &= \beta_1 before\, 2nd\, Wed + \beta_2 3rd\, Wed\, to\, 4th\, Wed + \beta_3 4th\, Wed\, to\, end\, month + \\ &\sum_{k=2}^{7} \gamma_k DOW_k + \tau_s DOS_s + \sum_{m=2}^{12} \phi_m Month_m + \sum_{y=1999}^{2008} \lambda_y Year_y + holiday_t + \epsilon_{i,t}, \end{aligned} \tag{11}$$

where $C^x_{i,t}$ is household i's expenditure on category x at day t; DOW_k are day of the week fixed effects; DOS_s is a variable indicating the day of (consumer unit i's) survey; $Month_m$ and; $Year_y$ are month and year fixed effects, and $holiday$ is an indicator variable for holidays. Coefficients β_1, β_2 and β_3 are our parameters of interest. Variable $before\, 2nd\, Wed$ equals 1 if the expenditure was made during the first days of the month, more precisely between the 1st day of the month and the day before the 2nd Wednesday of the month, and it is 0 otherwise. $3rd\, Wed\, to\, 4th\, Wed$ is a dummy variable that equals 1 if the expenditure was made on a day between the 3rd Wednesday of the month and the day before the 4th Wednesday, and it is 0 otherwise. Finally, the variable $4th\, Wed\, to\, end\, month$ indicates whether it was made during the last days of the month, i.e. between the 4th Wednesday and the last day of the month.

Table VIII shows the results of this exercise. I run equation (11) for 3 samples: (1) households with both spouses retired before 1997, i.e receiving paychecks on the 3rd of the month; (2) households where both spouses started receiving Social Security payments after 1997 (i.e paydays on the 2nd, 3rd or 4th Wednesdays of the month), and that were born in such dates that both are paid on the same Wednesday; (3) both types of households, i.e. paid on the 3rd of the month, 2nd, 3rd and 4th Wednesdays.

The estimates of equation (11) using the sample of couples receiving paychecks on the 3rd of the month (Panel A), show that their aggregate expenditure is significantly larger at the beginning of the month, that is, the days immediately after they received the paychecks (as in Stephens 2003). However, for the case of all couples with paychecks distributed on the 2nd, 3rd or 4th Wednesdays (Panel B), we observe a smoother aggregate expenditure over the month, and if something the expenditure is smaller during the first days when no one receive paychecks. By pooling all these households together (Panel C), I show that the within-month cycles finally disappear when retired couples get the paychecks only once a month but have paydays on different weeks (1/4 of households on the 3rd of the month, 1/4 on the 2nd Wednesday, 1/4 on the 3rd Wednesday, and 1/4 on the 4th Wednesday).[52]

Second, I run the specification (10) (described in Section IV.) for the sample of states with legislation requiring biweekly payments, in order to analyze the evolution of aggregate economic activity when paydays are distributed over the month. Under a biweekly payment cycle, workers receive checks with approximately the same frequency as in states with semi-monthly payments (every 2 weeks), however while in the case of a semi-monthly scheme paydays are the same for everybody it is not the case under biweekly payments. More precisely, under a biweekly pay schedule each company chooses a set day and issues payments every other week on that day; in the semi-monthly pay schedule paydays are usually set on the 1st and 15th of the month for everybody.

Results presented in Table XIII show that, although in this context the individual pay frequency is similar to the semi-monthly payment scheme, the aggregate economic activity is smoother in the biweekly setting. Columns 1 and 2 present, respectively, the estimations for the outcomes related to time spent shopping and time commuting for buying goods and services. While in the case of semi-monthly payments we observed that during the first week of the month and the week of the 15th people spent significantly more time on shopping related activities, in the context of biweekly payments there are not significantly differences on the time devoted to these activities over the month. The last columns report the results for the analysis of air pollution –carbon monoxide (Column 5) and particulate matter less than 10 microns in diameter (Column 6), showing a relatively stable level over the month and similar to the one present in states with a weekly payment scheme. The outcome variables of the regressions results shown in columns 3 and 4 are the number of traffic accidents and the number of fatalities. Similar to what we have

52. Although couples with 3rd of the month as a payday are systematically older than the others, it is not an issue in this analysis, because we are just showing that the cycle in aggregate expenditure could be reduced by distributing over the month the paydays of different people. Nevertheless, we do have to correct the weights in order to make the analysis presented in panel C of Table VIII. in our data there is an oversample of individuals getting paycheck on the 3rd of the month therefore, in order to weight equally the information provided by each household, in Panel C we weight observations by the inverse of the number of households in the same payment schedule (weight = 1,772/1,653 for couples getting the paychecks on the 1st of the month and weight = 1,772/119 for those with paydates on the 2nd, 3rd or 4th Wednesday).

seen in the case of states with semi-monthly and weekly schemes, under biweekly payments there is a higher levels of traffic accidents at the beginning of the month (also in the number of fatalities in those crashes). However, the pattern of traffic accidents is smoother over the rest of the month and we do not observe, as in the semi-monthly scheme, the peak during the week of the 15th.

Summarizing, these result show that spreading the paydays over the month is an alternative instrument to smooth the aggregate economic activity.

VI. Conclusions

This paper shows that the frequency with which individuals get their paychecks affects their expenditure decisions, which in turn has aggregate consequences. Thus, the paper points to the fact that the frequency with which someone is paid matters not only because it may affect her own wellbeing but also because it has an impact on others' wellbeing, as a result of congestion externalities.

I document that not all households smooth expenditure between paychecks, and that the ability to do this depends significantly on how frequently they get paid: the higher the frequency of payments, the smoother the within-month patterns of household expenditure, primarily for poorer households. I show that such individual effects translate into the aggregate economy, and then within-month business cycles emerge when many workers are paid at a low frequency and at the same time. In such a setting, the excessive accumulation of economic activity generated immediately after individuals are paid would cause congestion on paydays in sectors with capacity constraints (roads, hospitals, restaurants, supermarkets, etc.).

The evidence presented suggests that a competitive equilibrium may lead to suboptimally low pay frequencies, because of two failures: an individual failure, attributable to time-inconsistent preferences, and a market failure, the result of congestion externalities (note that the latter remains a concern even if the cycles are not generated by quasi-hyperbolic discounters). The existence of such failures calls for policy interventions, and the social planner will face several trade offs when deciding on the optimal pay frequencies. On the one hand, a higher pay frequency may act as a commitment device to smooth the expenditure of individuals with self-control problems, which directly increases such individuals' long-run utility and indirectly improves welfare through the reduction of negative congestion externalities. On the other hand, by increasing the frequency of payments, the actual cost of the labor unit goes up because total transaction costs increase.

In concrete terms, a policy that requires higher pay frequencies may be welfare improving if the short-run impatience of consumers is sufficiently high, the costs of congestion are considerable, or both, combined with low enough transaction costs. If the cost of processing more payments is high, keeping the same pay frequency but spreading the paydays of different firms more evenly throughout the month may also be welfare improving. In this latter case, the within-month business cycles generated by low pay frequencies will diminish and pay frequency will increase in those households with at least two earners working for different firms with apart enough paydays (assuming some degree of income pooling).

In most countries paychecks are distributed at even lower frequencies than in the United States (often monthly), and paydays are usually the same for all workers. Surprisingly, pay frequencies have remain relatively unchanged, despite the significantly reduction of administrative and transaction costs associated to processing paychecks. The evidence presented in this paper, which rises concerns about potential failures leading to inefficient market solutions, calls for further research on the optimal frequency of pay and the distribution of paydays.

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Tables

Table I: Frequency of social security payments: Retired couples

		Husband's birthday (day of month)		
		1st-10th	11th-20th	21st-31st
Wife's birthday (day of month)	1st-10th	**One payday**	Two paydays	Two paydays
	11th-20th	Two paydays	**One payday**	Two paydays
	21st-31st	Two paydays	Two paydays	**One payday**

Notes: Individuals born between the 1st and the 10th day of the month are paid on the 2nd Wednesday of each month; those born between the 11th and the 20th day of the month are paid on the 3rd Wednesday; and those born between the 21st and the 31st day of the month are paid on the 4th Wednesday.

Table II: Summary statistics and tests of mean differences: Demographic characteristics of households with two paydays and households with one payday

	Two Paydays	One Payday	Mean Difference
Husband's age	67.65	67.19	0.46
	(3.85)	(3.33)	(0.26)
Wife's age	65.95	65.67	0.28
	(3.41)	(2.81)	(0.44)
Household income	38881.02	37042.78	1838.24
	(33978.57)	(32691.38)	(0.62)
Couple's SS income	18833.33	18518.57	314.76
	(10808.08)	(9852.67)	(0.81)
Number of workers in house	0.05	0.08	-0.02
	(0.23)	(0.27)	(0.43)
Family size	2.16	2.12	0.05
	(0.55)	(0.32)	(0.38)
N (number of households)	273	119	

Notes: * Significant at 10%; **significant at 5%; *** significant at 1%. In columns 1 and 2 cells contain means (standard deviations are in parentheses). In column 3, cells contain mean differences (p values are in parentheses).

Table III: Summary statistics and tests of mean differences: Daily expenditure of households with two paydays and households with one payday

	Two Paydays	One Payday	Mean Difference
Total	136.77	116.29	20.48
	(547.86)	(351.71)	(0.18)
Nondurables	22.70	22.68	0.02
	(33.24)	(34.81)	(0.98)
Food	16.05	16.35	-0.30
	(27.09)	(27.61)	(0.72)
Food at home	10.00	11.06	-1.06
	(22.37)	(24.60)	(0.13)
Food away	6.05	5.30	0.75
	(14.07)	(12.55)	(0.07)*
Fresh food	1.70	1.85	-0.15
	(4.23)	(4.41)	(0.26)
Instant consumption	7.74	7.24	0.50
	(33.15)	(50.04)	(0.67)
N (number of households)	273	119	
Observations	3,542	1,553	

Notes: * Significant at 10%; **significant at 5%; *** significant at 1%. In columns 1 and 2 cells contain means (standard deviations are in parentheses). In column 3, cells contain mean differences (p values are in parentheses)

Table IV: Randomization test results

Panel A

	Husband age	Wife age	Household income	Household SS income	Number of workers in house	Family size
	(1)	(2)	(3)	(4)	(5)	(6)
Male, 11th-20th	0.13	-0.24	1265.84	695.26	-0.01	0.03
	(0.48)	(0.43)	(4357.65)	(1503.77)	(0.03)	(0.05)
Male, 21st-31th	-0.54	-0.32	2240.76	1138.72	-0.03	0.04
	(0.41)	(0.38)	(3940.11)	(1528.41)	(0.03)	(0.06)
Female, 11th-20th	-0.60	-0.47	-850.81	-394.23	-0.02	-0.06
	(0.46)	(0.39)	(4202.21)	(1466.53)	(0.03)	(0.06)
Female, 21st-31th	-0.53	-0.37	-532.01	-353.32	-0.04	-0.08
	(0.46)	(0.42)	(4189.31)	(1526.77)	(0.03)	(0.06)
N (number of households)	392	392	392	292	392	392

Panel B

	Husband age	Wife age	Household income	Household SS income	Number of workers in house	Family size
	(1)	(2)	(3)	(4)	(5)	(6)
Both spouses paid	-0.46	-0.28	-1838.24	-314.76	0.02	-0.05
same payday	(0.38)	(0.33)	(3631.30)	(1269.68)	(0.03)	(0.04)
N (number of households)	392	392	392	292	392	392

Notes: The sample includes all households with both spouses receiving Social Security payments who started receiving them after 1997. There are missing values in the SS income variable. The coefficient on "Both spouses paid same payday" in Panel B equals 1 if both spouses were born any day of the same interval of the month (1st-10th, 11th-20th or 21st-31st), then both should receive their paychecks in the same day every month. Clustered SE at the level of household are in parentheses. *** p0.01, ** p0.05, * p0.1.

Table V: Daily expenditure on the week of pay and frequency of payments (dollars)

	Total	Nondurables	Food	Food at home	Food away	Fresh food	Instant consumption
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
One Paycheck this Week	12.13	0.796	0.879	0.849	0.0294	0.0459	-0.623
	(21.02)	(1.636)	(1.392)	(1.112)	(0.602)	(0.182)	(1.772)
Two Paychecks this Week	34.26	3.943	4.791***	3.028*	1.763*	-0.0660	0.770
	(33.06)	(2.501)	(1.797)	(1.584)	(1.000)	(0.297)	(1.236)
Adj. R-squared	0.126	0.176	0.167	0.108	0.215	0.114	0.133
N (number of households)	392	392	392	392	392	392	392
Observations	5,095	5,095	5,095	5,095	5,095	5,095	5,095

Notes: The dependent variables are total expenditure in the following categories: total expenditure; nondurables; food and alcohol consumed at home; total food expenditure; food and alcohol consumed away from the household, fresh food, and instant consumption away from home. Values are deflated with the CPI into 2000 dollars. Days without reported expenditure are filled in with zeros. The sample includes all households with both spouses retired, who started receiving Social Security payments after 1997, and for whom I can infer their paydates. All regressions include the following control variables: a household fixed effect; day of the week fixed effects; a dummy variable equal to one if it is the sth day of (consumer unit i's) survey; month fixed effects; week of the month fixed effects; and an indicator variable for holidays. "One Paycheck this Week" equals 1 if, inferred from their birthdays, one and only one spouse received a paycheck between 0 and 6 days before day t and 0 otherwise. "Two Paychecks this Week" equals 1 if both spouses received their paycheck between 0 and 6 days before day t. Clustered SE at the level of household are in parentheses. *** p0.01, ** p0.05, * p0.1.

Table VI: Effects by income: Daily expenditure on the week of pay and frequency of payments

	Total	Nondurables	Food	Food at home	Food away	Fresh food	Instant consumption
	Panel A: Lower income quartile (Q1)						
One Paycheck this Week	-2.419	-0.849	0.840	-0.637	1.477	0.00256	4.072
	(16.96)	(2.797)	(2.212)	(1.687)	(1.000)	(0.351)	(3.681)
Two Paychecks this Week	-16.88	6.640***	7.032***	5.748***	1.284	1.076***	1.288
	(42.45)	(2.439)	(2.536)	(2.017)	(1.639)	(0.391)	(1.735)
Observations	1,238	1,238	1,238	1,238	1,238	1,238	1,238
F test for equality of coeff (p-value)	0.769	0.0454	0.0686	0.0193	0.918	0.0426	0.473
	Panel B: Second income quartile (Q2)						
One Paycheck this Week	-21.59	2.262	1.263	2.177	-0.914	0.186	-1.422
	(27.19)	(2.211)	(1.648)	(1.322)	(0.872)	(0.283)	(1.778)
Two Paychecks this Week	-46.02	-4.232	-0.873	-0.146	-0.728	-0.449	0.777
	(51.72)	(5.277)	(2.539)	(2.961)	(1.093)	(0.757)	(2.774)
Observations	1,232	1,232	1,232	1,232	1,232	1,232	1,232
F test for equality of coeff (p-value)	0.664	0.220	0.470	0.456	0.892	0.430	0.560
	Panel C: Third income quartile (Q3)						
One Paycheck this Week	22.87	0.568	-0.0136	-1.216	1.202	-0.579**	1.537
	(30.76)	(2.831)	(2.013)	(1.421)	(1.204)	(0.237)	(1.310)
Two Paychecks this Week	41.48	3.989	5.598	4.403	1.195	-0.301	0.638
	(75.68)	(5.403)	(4.351)	(4.671)	(1.878)	(0.603)	(1.988)
Observations	1,323	1,323	1,323	1,323	1,323	1,323	1,323
F test for equality of coeff (p-value)	0.811	0.568	0.234	0.249	0.997	0.664	0.706
	Panel D: Higher income quartile (Q4)						
One Paycheck this Week	37.49	-0.416	0.530	2.048	-1.518	0.324	-7.564
	(66.92)	(4.637)	(4.218)	(3.433)	(1.619)	(0.517)	(6.551)
Two Paychecks this Week	87.61	6.322	5.483	1.339	4.144*	-0.680	1.573
	(71.74)	(5.440)	(3.874)	(2.576)	(2.454)	(0.434)	(3.370)
Observations	1,302	1,302	1,302	1,302	1,302	1,302	1,302
F test for equality of coeff (p-value)	0.586	0.340	0.382	0.868	0.0490	0.139	0.229

Notes: The dependent variables are total expenditure in the following categories: total expenditure; nondurables; food and alcohol consumed at home; total food expenditure; food and alcohol consumed away from the household, fresh food, and instant consumption away from home. Values are deflated with the CPI into 2000 dollars. Days without reported expenditure are filled in with zeros. The sample includes all households with both spouses retired, who started receiving Social Security payments after 1997, and for whom I can infer their paydates. All regressions include the following control variables: a household fixed effect; day of the week fixed effects; a dummy variable equal to one if it is the sth day of (consumer unit i's) survey; month fixed effects; week of the month fixed effects; and an indicator variable for holidays. "One Paycheck this Week" equals 1 if, inferred from their birthdays, one and only one spouse received a paycheck between 0 and 6 days before day t and 0 otherwise. "Two Paychecks this Week" equals 1 if both spouses received their paycheck between 0 and 6 days before day t. Clustered SE at the level of household are in parentheses. *** p0.01, ** p0.05, * p0.1.

Table VII: Test of income pooling: Sample of households in the lower income quartile (Q1)

	Total	Non-durables	Food	Food at home	Food away	Fresh food	Instant consumption	Cloth (total)	Men's cloth	Women's cloth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
One Paycheck this Week	-11.10	-1.443	0.0226	-1.512	1.534	0.0603	2.996	-0.354	1.250	0.653
	(19.28)	(3.375)	(2.733)	(2.121)	(1.119)	(0.412)	(2.549)	(0.900)	(1.456)	(2.093)
One Paycheck this Week ∗	9.084	-0.0628	1.924	0.523	1.401	-0.0739	5.498	-1.643	1.691	0.228
Husband's Paycheck	(27.93)	(3.377)	(2.564)	(2.079)	(1.144)	(0.456)	(5.403)	(1.401)	(1.101)	(1.880)
Two Paychecks this Week	-17.04	6.629***	7.017***	5.732***	1.285	1.077***	1.269	2.430*	1.296**	3.973**
	(42.41)	(2.442)	(2.543)	(2.025)	(1.639)	(0.391)	(1.730)	(1.370)	(0.591)	(1.847)
N (number of households)	98	98	98	98	98	98	98	98	98	98
Observations	1,238	1,238	1,238	1,238	1,238	1,238	1,238	1,238	1,238	1,238

Notes: Dependent variables are total expenditure in the following categories: total expenditure; nondurables; food and alcohol consumed at home; total food expenditure; food and alcohol consumed away from the household; fresh food; instant consumption away from home; total cloth; men's cloth and women's cloth. Values are deflated with the CPI into 2000 dollars. Days without reported expenditure are filled in with zeros. The sample includes all poor households (the lower income quartile) with both spouses retired, who started receiving Social Security payments after 1997, and for whom I can infer their paydates. All regressions include the following control variables: a household fixed effect; day of the week fixed effects; a dummy variable equal to one if it is the sth day of (consumer unit i's) survey; month fixed effects; week of the month fixed effects; and an indicator variable for holidays. "One Paycheck this Week" equals 1 if, inferred from their birthdays, one and only one spouse received a paycheck between 0 and 6 days before day t and 0 otherwise. "Two Paychecks this Week" equals 1 if both spouses received their paycheck between 0 and 6 days before day t. The coefficient of the interaction "One Paycheck this Week * Husband's Paycheck" represents the difference in choice outcomes that could emerge if was not the wife but the husband the one receiving the paycheck on that week. Clustered SE at the level of household are in parentheses. *** p0.01, ** p0.05, * p0.1.

Table VIII: Timing of pay and aggregate daily expenditure (dollars)

Sample: Retired couples with one payday (both spouses get the paychecks on the same date).

	Total	Nondurables	Food	Food at home	Food away	Fresh food	Instant consumption
	Panel A. One payday: 3rd of the month						
1st of the month to 2nd Wed	18.00***	1.405**	0.992**	0.733**	0.259	0.155**	-0.269
	(5.602)	(0.581)	(0.490)	(0.332)	(0.339)	(0.0667)	(0.586)
3rd Wed to 4th Wed	-2.158	0.384	0.421	0.760**	-0.339	0.198***	-0.781
	(7.218)	(0.534)	(0.448)	(0.373)	(0.226)	(0.0747)	(0.478)
4th Wed to end of the month	8.374	0.0959	0.136	0.113	0.0229	0.0450	-0.454
	(9.713)	(0.589)	(0.485)	(0.375)	(0.280)	(0.0788)	(0.479)
N (number of households)	1,653	1,653	1,653	1,653	1,653	1,653	1,653
Observations	21,649	21,649	21,649	21,649	21,649	21,649	21,649
	Panel B. Three paydates: 2nd, 3rd and 4th Wednesday of the month						
1st of the month to 2nd Wed	-24.42	-4.187	-3.483*	-1.655	-1.829*	-0.677**	-7.463
	(29.54)	(2.774)	(2.071)	(1.762)	(0.943)	(0.269)	(5.679)
3rd Wed to 4th Wed	-38.05	0.115	-0.301	-0.292	-0.00873	-0.219	-5.658
	(31.03)	(2.405)	(1.726)	(1.386)	(0.974)	(0.258)	(6.218)
4th Wed to end of the month	-54.21**	-4.582	-3.603	-1.820	-1.782	-0.286	-5.954
	(26.85)	(3.082)	(2.327)	(1.900)	(1.130)	(0.348)	(4.811)
N (number of households)	119	119	119	119	119	119	119
Observations	1,553	1,553	1,553	1,553	1,553	1,553	1,553
	Panel C. Four paydates: 3rd of the month, 2nd, 3rd and 4th Wednesday						
1st of the month to 2nd Wed	-3.888	-1.143	-1.008	-0.399	-0.609	-0.243*	-3.364
	(14.00)	(1.283)	(0.964)	(0.799)	(0.473)	(0.130)	(2.604)
3rd Wed to 4th Wed	-18.85	0.704	0.492	0.500	-0.00854	0.0556	-2.596
	(14.77)	(1.160)	(0.855)	(0.686)	(0.488)	(0.132)	(2.695)
4th Wed to end of the month	-22.24	-1.677	-1.228	-0.614	-0.614	-0.0878	-2.689
	(13.65)	(1.459)	(1.106)	(0.883)	(0.561)	(0.174)	(2.269)
N (number of households)	1,772	1,772	1,772	1,772	1,772	1,772	1,772
Observations	23,202	23,202	23,202	23,202	23,202	23,202	23,202

Notes: The dependent variables are total expenditure in the following categories: total expenditure; nondurables; food and alcohol consumed at home; total food expenditure; food and alcohol consumed away from the household, fresh food, and instant consumption away from home. Values are deflated with the CPI into 2000 dollars. Days without reported expenditure are filled in with zeros. The sample includes households with both spouses retired and where both have the same paydate of Social Security benefits. Panel A includes households with both spouses retired before 1997, i.e receiving paychecks on the 3rd of the month. Panel B includes households where both spouses started receiving Social Security payments after 1997 (i.e paydates on the 2nd, 3rd or 4th Wednesdays of the month) and that were born in such dates that both are paid on the same Wednesday. Panel C includes both types of households (paid on the 3rd of the month, 2nd, 3rd and 4th Wednesdays). In order to weight equally the information provided by each household, in Panel C observations are weighted by the inverse of the number of households in the same payment schedule (weight = 1,772/1,653 for couples getting the paychecks on the 1st of the month and weight = 1,772/119 for those with paydates on the 2nd, 3rd or 4th Wednesday). All regressions include the following control variables: day of the week fixed effects; a variable indicating the day of (consumer unit i's) survey (range 1 to 14); month fixed effects; year fixed effects and an indicator variable for holidays. "1st of the month to 2nd Wed" equals 1 if the expenditure was made between the 1st day of the month and before the 2nd Wednesday, and 0 otherwise. "3rd Wed to 4th Wed" equals 1 if the expenditure was made between the 3rd Wednesday of the month and before the 4rd Wednesday. "4th Wed to end of the month" equals 1 if the expenditure was made between the 4th Wednesday and the last day of the month. Clustered SE at the level of household are in parentheses. *** p0.01, ** p0.05, * p0.1.

Table IX: Summary statistics: Air pollution, traffic accidents, and time use (daily measures)

	States requiring weekly payments	States requiring semi-monthly payments
	Panel A: *Time Use (minutes)*	
All goods and services	48.6	47.6
	(81.4)	(82.8)
Travel related to shopping	18.2	17.3
	(36)	(36.5)
Observations	17,556	56,721
	Panel B: *Traffic Accidents*	
Accidents	1.25	2.31
	(1.72)	(2.97)
Fatalities	1.35	2.57
	(1.90)	(3.38)
Observations	30,100	86,000
	Panel C: *Air Pollution*	
CO	0.46	0.52
	(0.31)	(0.38)
Observations	295,810	176,7140
O3	0.03	0.03
	(0.01)	(0.01)
Observations	253,130	1,875,466
PM10	20.53	27.94
	(14.73)	(33.36)
Observations	44,308	774,800

Notes: Cells contain means. Standard deviations are in parentheses.

Table X: Time spent obtaining goods and services and frequency of payments

	States requiring weekly payments		States requiring semi-monthly payments	
	All goods and services	Travel related to shopping	All goods and services	Travel related to shopping
	(1)	(2)	(3)	(4)
2 weeks before (15th) pay	-0.199	0.075	2.615**	1.394***
($week_{-2}$)	(2.033)	(0.890)	(1.188)	(0.525)
week of (15th) pay	2.046	1.129	3.419***	1.252**
($week_0$)	(2.290)	(0.966)	(1.206)	(0.523)
2nd week after (15th) pay	2.170	1.573	0.723	0.165
($week_1$)	(2.112)	(0.993)	(1.298)	(0.544)
Adj. R-squared	0.031	0.012	0.028	0.010
N	17556	17556	56721	56721

Notes: The outcome variable of regressions of columns 1 and 3 is time spent obtaining goods and services, which includes all time spent acquiring any goods or services. In columns 2 and 4, the RHS variable includes time spent on travel related to purchasing goods and services. The sample used in the regressions shown in columns 1 and 2 includes states with legislation requiring weekly payments. In columns 3 and 4 the sample includes states requiring semi-monthly payments. All regressions include the following control variables: state, month, year and day of week fixed effects, an indicator variable for holidays, and a set of demographic characteristics (gender, race, age, number of children and labor status). "Week of (15th) pay" equals 1 if that day is 1 to 7 days from the 15th of the month (or the Friday before if 15th is on a weekend). Clustered SE at the level of date are in parentheses. *** p0.01, ** p0.05, * p0.1.

Table XI: Traffic accidents, fatalities and frequency of payments

	States requiring weekly payments		States requiring semi-monthly payments	
	Accidents	Fatalities	Accidents	Fatalities
	(1)	(2)	(3)	(4)
2 weeks before (15th) pay	0.036*	0.034	0.067***	0.075***
($week_{-2}$)	(0.019)	(0.022)	(0.017)	(0.020)
week of (15th) pay	0.005	-0.001	0.037**	0.045**
($week_0$)	(0.019)	(0.021)	(0.016)	(0.019)
2nd week after (15th) pay	-0.005	-0.001	0.011	0.019
($week_1$)	(0.019)	(0.021)	(0.016)	(0.019)
Adj. R-squared	0.533	0.512	0.681	0.655
N	30100	30100	86000	86000

Notes: The dependent variables are the number of accidents or the number of fatalities. The sample used in the regressions shown in columns 1 and 2 includes states with legislation requiring weekly payments. In columns 3 and 4 the sample includes states requiring semi-monthly payments. All regressions include the following control variables: state, month, year and day of week fixed effects, and an indicator variable for holidays. "Week of (15th) pay" equals 1 if that day is 1 to 7 days from the 15th of the month (or the Friday before if 15th is on a weekend). Clustered SE at the level of date are in parentheses. *** p0.01, ** p0.05, * p0.1.

Table XII: Air pollution and frequency of payments

	States requiring weekly payments		States requiring semi-monthly payments	
	CO	PM10	CO	PM10
	(1)	(2)	(3)	(4)
2 weeks before (15th) pay	-0.002737	0.373522	0.010906***	0.817985**
($week_{-2}$)	(0.004334)	(0.650221)	(0.003893)	(0.357740)
week of (15th) pay	-0.010272**	0.368573	0.006883*	0.652586*
($week_0$)	(0.004148)	(0.540230)	(0.003598)	(0.333724)
2nd week after (15th) pay	-0.010107**	-0.129823	-0.006917*	-0.491231
($week_1$)	(0.004378)	(0.551704)	(0.003613)	(0.306994)
Adj. R-squared	0.422	0.296	0.381	0.151
N	295810	44308	1767140	774800

Notes: The dependent variables are one of the following measures of pollution: carbon monoxide (CO) or particulate matter less than 10 microns in diameter (PM10). The sample used in the regressions shown in columns 1 and 2 includes states with legislation requiring weekly payments. In columns 3 and 4 the sample includes states requiring semi-monthly payments. All regressions include the following control variables: city, month, year and day of week fixed effects, and an indicator variable for holidays. “Week of (15th) pay” equals 1 if that day is 1 to 7 days from the 15th of the month (or the Friday before if 15th is on a weekend). Clustered SE at the level of date are in parentheses. *** p0.01, ** p0.05, * p0.1.

Table XIII: Timing of pay and the pattern of aggregate economic activity

Sample of states requiring a biweekly pay frequency of wage payments.

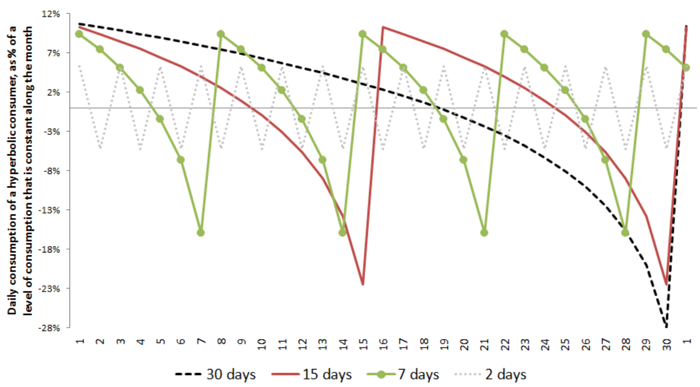
	All goods and services	Travel related to shopping	Accidents	Fatalities	CO	PM10
	(1)	(2)	(3)	(4)	(5)	(6)
2 weeks before (15th) pay ($week_{-2}$)	-4.062	-0.171	0.0708**	0.0817**	-0.00766	0.366
	(3.491)	(1.586)	(0.0327)	(0.0378)	(0.00492)	(0.485)
week of (15th) pay ($week_0$)	-5.189	-1.171	-0.0168	-0.0104	-0.00521	-0.638
	(3.488)	(1.460)	(0.0317)	(0.0367)	(0.00475)	(0.457)
2nd week after (15th) pay ($week_1$)	-1.086	0.0522	-0.0395	-0.0406	-0.0132***	-0.425
	(4.047)	(1.719)	(0.0307)	(0.0360)	(0.00471)	(0.453)
Adj. R-squared	0.039	0.017	0.161	0.150	0.244	0.150
N	6,164	6,164	12,900	12,900	111,398	57,191

Notes: The sample used in all regressions includes states with legislation requiring biweekly payments. The outcome variables of regressions of columns 1 and 2 are, respectively, time spent obtaining goods and services and time spent on travel related to purchasing goods and services. Regressions in columns 1 and 2 include the following control variables: state, month, year and day of week fixed effects, an indicator variable for holidays, and a set of demographic characteristics (gender, race, age, number of children and labor status). In columns 3 and 4 the dependent variables are, respectively, the number of accidents and the number of fatalities. These regressions include the following control variables: state, month, year and day of week fixed effects, and an indicator variable for holidays. Finally, the outcome variables of the regressions results shown in columns 5 and 6 are the following measures of pollution: carbon monoxide (CO, column 5) and particulate matter less than 10 microns in diameter (PM10, column 6). "Week of (15th) pay" equals 1 if that day is 1 to 7 days from the 15th of the month (or the Friday before if 15th is on a weekend). Clustered SE at the level of date are in parentheses. *** p0.01, ** p0.05, * p0.1.

Appendix

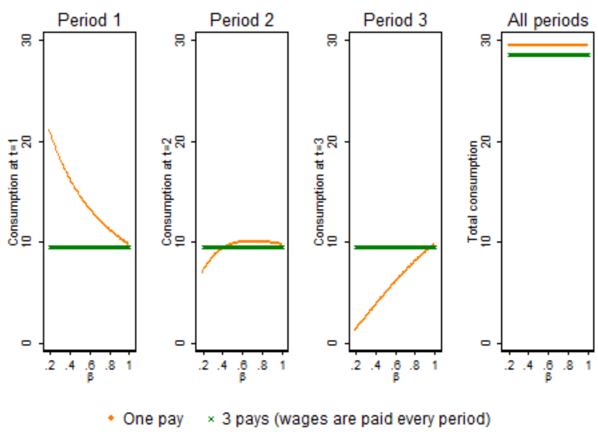
A. Figures

Figure A.1: Daily consumption under different frequencies of wage payment



Notes: Log utility function and $\beta = 0.9$.

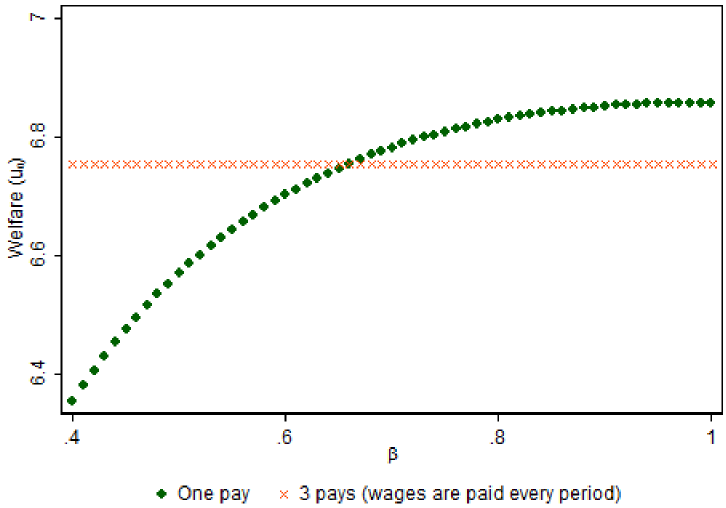
Figure A.2: Consumption paths under different pay frequencies and β



Notes: The first three panels show consumption levels at each period of time, and the last panel aggregates total consumption in all periods, for a worker with period utility: $u_t = ln(c_t) + \beta\,(ln(c_{t+1}) + ln(c_{t+2}))$. Green lines display consumption levels when the worker receives only one upfront payment for the three periods (one pay of $3w - \gamma$). Red (flat) lines show consumption when a worker is paid at the beginning of every period (three pays of $w - \gamma$). Parameter values: wage (w)=10; transaction cost (γ)=0.5.

Figure A.3: WELFARE UNDER DIFFERENT PAY FREQUENCIES AND β

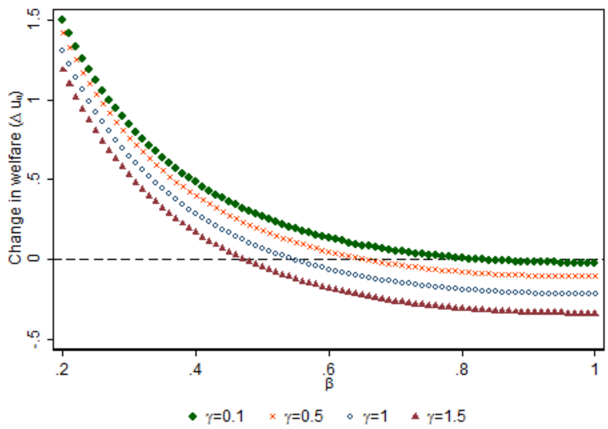
Model without congestion costs



Notes: This figure shows consumer's welfare for a worker with period utility: $u_t = ln(c_t) + \beta\,(ln(c_{t+1}) + ln(c_{t+2}))$. Green line shows total welfare when the worker receives one upfront payment for the three periods (one pay of $3w - \gamma$). Red (flat) line shows the case when a worker is paid at the beginning of every period (three pays of $w - \gamma$). Parameter values: wage (w)=10; transaction cost (γ)=0.5.

Figure A.4: WELFARE, PAY FREQUENCY, AND TRANSACTION COSTS

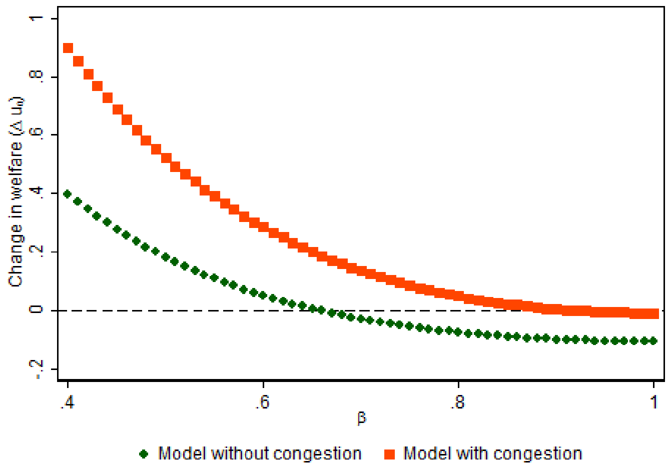
Model without congestion costs
Change in welfare when pay frequency increases, under different β's and *γ's*



Notes: This figure shows changes in consumer's welfare under different levels of short-term discount rate (β) and transaction cost (γ), when the frequency of wage payments is changed from one upfront payment at t=0 (one pay of $3w-\gamma$) to payments in every period (three pays of $w-\gamma$). Parametrization: wage (w)=10.

Figure A.5: CHANGE IN WELFARE WHEN PAY FREQUENCY INCREASES

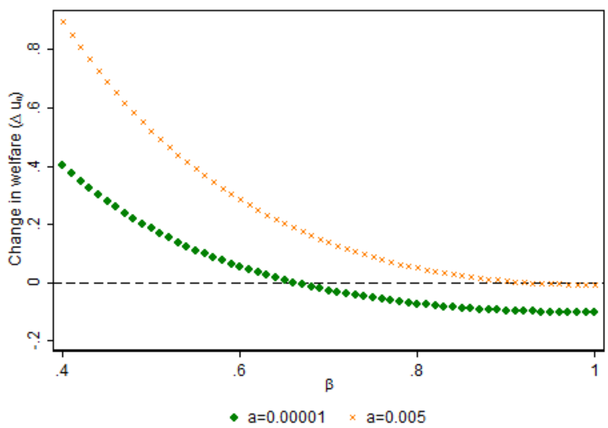
Models with and without congestion costs



Notes: This figure shows, for the cases with and without congestion costs, the changes in consumer's welfare under different levels of short-term discount rate (β), when frequency of wage payment is changed from one upfront payment (one pay of $3w - \gamma$) to payments in every period (three pays of $w - \gamma$). Parameter values: wage (w)=10; transaction cost (γ)=0.5, and (a)=0.01.

Figure A.6: CHANGE IN WELFARE WHEN PAY FREQUENCY INCREASES, UNDER DIFFERENT LEVELS OF CONGESTION COSTS (a) AND β

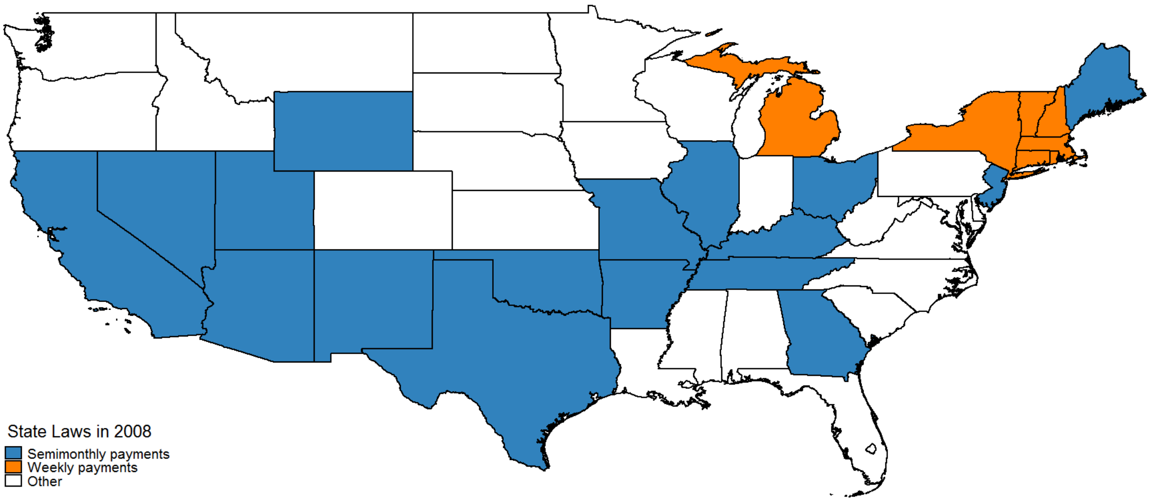
Model with congestion costs



Notes: This figure shows changes in consumer's welfare under different levels of short-term discount rate (β) and congestion costs (a), when frequency of wage payment is changed from one upfront payment (one pay of $3w - \gamma$) to payments in every period (three pays of $w - \gamma$). Parameter values: wage (w)=10 and transaction cost (γ)=0.5.

A.I. *States Requiring Semi-monthly or Weekly Payments of Wages in 2008*

Figure A.7: State laws regulating the frequency of wage payments in the United States



B. Summary Statistics by Income Quartile

Table B.1: Demographic characteristics of households with two paydays and households with one payday, by household's income

	Two Paydays	One Payday	Mean Difference
Panel A: Lower income quartile (Q1)			
Husband's age	69.01	67.53	1.48
	(5.87)	(4.31)	(0.22)
Wife's age	66.82	66.30	0.52
	(4.90)	(3.41)	(0.60)
Household income	7977.19	8605.93	-628.75
	(6552.35)	(6915.18)	(0.67)
Couple's SS income	7062.96	7596.97	-534.00
	(6684.55)	(6333.71)	(0.72)
Number of workers in house	0.01	0.07	-0.05
	(0.12)	(0.25)	(0.17)
Family size	2.10	2.10	0.00
	(0.43)	(0.31)	(0.97)
Panel B: Second income quartile (Q2)			
Husband's age	66.92	67.60	-0.68
	(2.77)	3.17)	(0.27)
Wife's age	65.57	65.37	0.20
	(2.75)	(2.65)	(0.73)
Household income	24292.92	24091.97	200.95
	(3751.16)	(3393.75)	(0.79)
Couple's SS income	21193.83	21461.36	-267.53
	(5600.28)	(5953.19)	(0.85)
Number of workers in house	0.05	0.03	0.02
	(0.21)	(0.17)	(0.65)
Family size	2.13	2.11	0.01
	(0.38)	(0.32)	(0.87)
Panel C: Third income quartile (Q3)			
Husband's age	67.66	67.25	0.41
	(2.85)	(3.06)	(0.53)
Wife's age	65.74	66.21	-0.47
	(2.71)	(2.79)	(0.44)
Household income	38873.88	38200.51	673.37
	(4867.67)	(4547.15)	(0.53)
Couple's SS income	23666.94	22121.70	1545.24
	(9500.94)	(7162.67)	(0.51)
Number of workers in house	0.04	0.11	-0.06
	(0.20)	(0.31)	(0.23)
Family size	2.13	2.11	0.02
	(0.54)	(0.31)	(0.84)
Panel D: Higher income quartile (Q4)			
Husband's age	67.00	66.19	0.81
	(2.63)	(2.35)	(0.17)
Wife's age	65.65	64.77	0.88
	(2.66)	(2.01)	(0.13)
Household income	80839.51	86041.52	-5202.02
	(38188.65)	(35317.30)	(0.55)
Couple's SS income	25328.29	27533.33	-2205.04
	(9035.37)	(6164.76)	(0.35)
Number of workers in house	0.11	0.12	-0.00
	(0.32)	(0.33)	(0.95)
Family size	2.29	2.15	0.14
	(0.74)	(0.37)	(0.37)

Notes: * Significant at 10%; **significant at 5%; *** significant at 1%. In columns 1 and 2 cells contain means (standard deviations are in parentheses). In column 3, cells contain mean differences (p values are in parentheses).

C. Robustness Checks

In this Appendix I present different robustness checks to test the strength of the results presented in the paper. I start by showing that results of Subsection III.D. are robust to not imputing with zeros the expenditure of days without information in the CEX survey diary (Tables C.1 and C.3). I also present the results of equation (7) without controlling for week of the month fixed effects (Tables C.2 and C.3). Table C.4 shows the results of the test of income pooling that was discussed for the sample of poor couples in Subsection III.D.2., but now the analysis includes the whole sample of couples used in the baseline specification.

Finally, Table C.5 presents a robustness check of the main results of air pollution and frequency of payments. I run a placebo test by analyzing the evolution of ozone levels within the month. Ozone is the other pollutant popularly used in the economic literature, and it is known for being uncorrelated with economics activity.

Table C.1: Daily expenditure on the week of pay and frequency of payments

Robustness checks to not filling with zeros expenditure variables of days without reported expenditure

	Total	Nondurables	Food	Food at home	Food away	Fresh food	Instant consumption
				Panel A: All households			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
One Paycheck this Week	19.47	0.817	0.920	0.959	-0.0387	0.0463	-1.049
	(28.11)	(2.167)	(1.904)	(1.553)	(0.763)	(0.252)	(2.391)
Two Paychecks this Week	43.56	4.643*	5.963***	3.954**	2.009	-0.0664	0.498
	(43.90)	(2.746)	(2.118)	(1.939)	(1.267)	(0.362)	(1.659)
N	3,899	3,899	3,899	3,899	3,899	3,899	3,899
				Panel B: Lower income quartile (Q1)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
One Paycheck this Week	-13.14	-2.640	0.0952	-1.613	1.708	-0.0588	5.415
	(25.80)	(3.769)	(3.087)	(2.539)	(1.332)	(0.494)	(5.362)
Two Paychecks this Week	-19.27	6.805*	8.444**	7.600**	0.845	1.521**	0.219
	(42.92)	(3.894)	(3.821)	(2.992)	(2.699)	(0.608)	(3.002)
N	900	900	900	900	900	900	900

Notes: The dependent variables are total expenditure in the following categories: total expenditure; nondurables; food and alcohol consumed at home; total food expenditure; food and alcohol consumed away from the household; fresh food; and instant consumption away from home. Values are deflated with the CPI into 2000 dollars. The sample includes all households with both spouses retired, receiving Social Security payments when retired after 1997. All regressions include the following control variables: a household fixed effect; day of the week fixed effects; a dummy variable equal to one if it is the sth day of (consumer unit i's) survey; week fixed effects; month fixed effects; and an indicator variable for holidays. "One Paycheck this Week" equals 1 if one and only one spouse received a paycheck between 0 and 6 days before day t and 0 otherwise. "Two Paychecks this Week" equals 1 if both spouses received their paycheck between 0 and 6 days before day t. Clustered SE at the level of household are in parentheses. *** p0.01, ** p0.05, * p0.1.

Table C.2: Daily expenditure on the week of pay and frequency of payments

Robustness checks to not controlling by week of the month fixed effects

	Total	Nondurables	Food	Food at home	Food away	Fresh food	Instant consumption
				Panel A: All households			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
One Paycheck this Week	2.301	0.675	0.798	0.925	-0.127	0.0738	-1.146
	(17.12)	(1.572)	(1.302)	(1.022)	(0.579)	(0.172)	(2.135)
Two Paychecks this Week	29.60	3.835	4.749***	3.037*	1.711*	-0.0585	0.498
	(32.97)	(2.486)	(1.787)	(1.582)	(1.002)	(0.296)	(1.231)
N	5,095	5,095	5,095	5,095	5,095	5,095	5,095
				Panel B: Lower income quartile (Q1)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
One Paycheck this Week	-21.65	-1.080	0.115	-1.066	1.181	-0.0874	3.640
	(17.10)	(2.812)	(2.286)	(1.713)	(1.001)	(0.344)	(3.517)
Two Paychecks this Week	-19.47	6.625***	6.754***	5.571***	1.183	1.076***	0.915
	(42.41)	(2.342)	(2.497)	(1.981)	(1.631)	(0.387)	(1.719)
N	1,238	1,238	1,238	1,238	1,238	1,238	1,238

Notes: The dependent variables are total expenditure in the following categories: total expenditure; nondurables; food and alcohol consumed at home; total food expenditure; food and alcohol consumed away from the household; fresh food; and instant consumption away from home. Values are deflated with the CPI into 2000 dollars. Days without reported expenditure are filled in with zeros. The sample includes all households with both spouses retired, who started receiving Social Security payments after 1997, and for whom I can infer their paydates. All regressions include the following control variables: a household fixed effect; day of the week fixed effects; a dummy variable equal to one if it is the sth day of (consumer unit i's) survey; month fixed effects; and an indicator variable for holidays. "One Paycheck this Week" equals 1 if one and only one spouse received a paycheck between 0 and 6 days before day t and 0 otherwise. "Two Paychecks this Week" equals 1 if both spouses received their paycheck between 0 and 6 days before day t. Clustered SE at the level of household are in parentheses. *** p0.01, ** p0.05, * p0.1.

Table C.3: Daily expenditure on the week of pay and frequency of payments

Robustness checks to not filling with zeros expenditure variables of days without reported expenditure and not controlling by week of the month fixed effects

	Total	Nondurables	Food	Food at home	Food away	Fresh food	Instant consumption
	Panel A: All households						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
One Paycheck this Week	7.265	1.117	1.208	1.252	-0.0445	0.101	-1.525
	(22.67)	(2.108)	(1.783)	(1.423)	(0.741)	(0.235)	(2.881)
Two Paychecks this Week	38.36	4.625*	6.014***	4.009**	2.005	-0.0518	0.226
	(43.79)	(2.734)	(2.115)	(1.952)	(1.263)	(0.366)	(1.648)
N	3,899	3,899	3,899	3,899	3,899	3,899	3,899
	Panel B: Lower income quartile (Q1)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
One Paycheck this Week	-32.53	-2.334	-0.297	-1.916	1.619	-0.130	5.213
	(22.94)	(3.694)	(3.011)	(2.437)	(1.326)	(0.466)	(5.129)
Two Paychecks this Week	-23.35	6.996*	8.314**	7.512**	0.802	1.540**	-0.153
	(44.76)	(3.889)	(3.860)	(3.001)	(2.691)	(0.610)	(3.068)
N	900	900	900	900	900	900	900

Notes: The dependent variables are total expenditure in the following categories: total expenditure; nondurables; food and alcohol consumed at home; total food expenditure; food and alcohol consumed away from the household; fresh food; and instant consumption away from home. Values are deflated with the CPI into 2000 dollars. The sample includes all households with both spouses retired, who started receiving Social Security payments after 1997, and for whom I can infer their paydates. All regressions include the following control variables: a household fixed effect; day of the week fixed effects; a dummy variable equal to one if it is the sth day of (consumer unit i's) survey; month fixed effects; and an indicator variable for holidays. "One Paycheck this Week" equals 1 if one and only one spouse received a paycheck between 0 and 6 days before day t and 0 otherwise. "Two Paychecks this Week" equals 1 if both spouses received their paycheck between 0 and 6 days before day t. Clustered SE at the level of household are in parentheses. *** p0.01, ** p0.05, * p0.1.

Table C.4: Test of Income Pooling: All Sample

	Total	Non-durables	Food	Food at home	Food away	Fresh food	Instant consumption	Cloth (total)	Men's cloth	Women's cloth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(10)	(9)	(8)
One Paycheck this Week	8.958	-0.422	-0.0737	-0.166	0.0923	0.0470	-0.726	-2.566	-0.0870	-2.226
	(28.42)	(2.117)	(1.810)	(1.472)	(0.714)	(0.238)	(1.450)	(1.794)	(0.486)	(1.911)
One Paycheck this Week ∗	15.00	1.898	1.741	1.769	-0.0277	0.0448	-0.529	-4.398	0.284	-3.333
Husband's Paycheck	(20.78)	(1.646)	(1.355)	(1.085)	(0.718)	(0.203)	(2.190)	(3.952)	(0.422)	(4.017)
Two Paychecks this Week	34.25	3.942	4.790***	3.027*	1.763*	-0.0660	0.769	1.659	0.484	2.335
	(33.06)	(2.502)	(1.798)	(1.586)	(1.000)	(0.297)	(1.236)	(1.271)	(1.330)	(1.777)
N	5,095	5,095	5,095	5,095	5,095	5,095	5,095	5,095	5,095	5,095

Notes: Dependent variables are total expenditure in the following categories: total expenditure; nondurables; food and alcohol consumed at home; total food expenditure; food and alcohol consumed away from the household; fresh food; instant consumption away from home; total cloth; men's cloth and women's cloth. Values are deflated with the CPI into 2000 dollars. Days without reported expenditure are filled in with zeros. The sample includes all households with both spouses retired, who started receiving Social Security payments after 1997, and for whom I can infer their paydates. All regressions include the following control variables: a household fixed effect; day of the week fixed effects; a dummy variable equal to one if it is the sth day of (consumer unit i's) survey; month fixed effects; week of the month fixed effects; and an indicator variable for holidays. "One Paycheck this Week" equals 1 if, inferred from their birthdays, one and only one spouse received a paycheck between 0 and 6 days before day t and 0 otherwise. "Two Paychecks this Week" equals 1 if both spouses received their paycheck between 0 and 6 days before day t. The coefficient of the interaction "One Paycheck this Week * Husband's Paycheck" represents the difference in choice outcomes that could emerge if was not the wife but the husband the one receiJanving the paycheck on that week. Clustered SE at the level of household are in parentheses. *** p0.01, ** p0.05, * p0.1.

Table C.5: Placebo Check for Air pollution: Ozone and frequency of payments

	Ozone (O_3)	
	States requiring weekly payments	States requiring semi-monthly payments
	(1)	(2)
2 weeks before (15th) pay	0.000479	0.000124
($week_{-2}$)	(0.000305)	(0.000123)
week of (15th) pay	0.000179	0.000084
($week_0$)	(0.000297)	(0.000117)
2nd week after (15th) pay	-0.000299	0.000065
($week_1$)	(0.000306)	(0.000121)
Adj. R-squared	0.381	0.488
N	253130	1875466

Notes: The dependent variable is Ozone. The sample used in the regressions shown in column 1 includes states with legislation requiring weekly payments. In column 2 the sample includes states requiring semi-monthly payments. All regressions include the following control variables: city, month, year and day of week fixed effects, and an indicator variable for holidays. "Week of (15th) pay" equals 1 if that day is 1 to 7 days from the 15th of the month (or the Friday before if 15th is on a weekend). Clustered SE at the level of date are in parentheses. *** p0.01, ** p0.05, * p0.1.

D. Solution of the Model

Here I present the solution of the model discussed in Section II.. I solve the model using backward induction, beginning in period three.

D.I. *Case 1: Equilibrium When Worker Is Paid at a Low Frequency (With One Upfront Pay of* $3w-\gamma$ *at t=1)*

Period $t = 3$

$$\max_{c_3} u_3 = ln(c_3)$$

$$s.t: \; c_3 \leq s_2^*$$

$$c_3^* = s_2^* \tag{B.1}$$

Because the agent will die at the end of period 3, he would not keep anything for the next period and the consumption of the last period equals savings when entering this period (s_i^* are the savings at the end of period i).

Period $t = 2$

$$\max_{c_2,c_3} u_2 = ln(c_2) + \beta ln(c_3)$$

$$s.t: \; c_2 + c_3 = s_1^*$$

$$\Rightarrow c_3 = s_1^* - c_2$$

$$\max_{c_2} u_2 = ln(c_2) + \beta ln(s_1 - c_2)$$

$$FOC: \; \frac{1}{c_2} - \beta\frac{1}{s_1^* - c_2} = 0$$

$$c_2^* = \frac{s_1^*}{1+\beta} \tag{B.2}$$

$$s_2^* = \frac{\beta s_1^*}{1+\beta} \tag{B.3}$$

Period $t = 1$

$$\max_{c_1,c_2,c_3} u_1 = ln(c_1) + \beta\,(ln(c_2) + ln(c_3))$$

$$s.t\; c_1 + c_2 + c_3 = 3w - \gamma$$

$$Let's\, define\, s_1 = 3w - \gamma - c_1,\; then\; c_3 = s_1 - c_2$$

$$FOC \begin{cases} \max\limits_{s_1,c_2} u_1 = ln(3w - \gamma - s_1) + \beta\,(ln(c_2) + ln(s_1 - c_2)) \\ \frac{\partial u_1}{\partial s_1}\; \frac{-1}{3w-\gamma-s_1} + \beta\frac{1}{s_1-c_2} = 0 \\ \Rightarrow s_1 = \frac{\beta m(3w-\gamma)+c_2}{1+\beta} \\ \frac{\partial u_1}{\partial c_2}\; \frac{\beta}{c_2} - \frac{\beta}{s_1-c_2} = 0 \\ \Rightarrow s_1 = 2c_2 \end{cases}$$

$$\frac{\beta(3w-\gamma)+c_2}{1+\beta} = 2c_2$$

$$c_2 = \frac{\beta(3w-\gamma)}{1+2\beta}$$

$$s_1^* = \frac{2\beta(3w-\gamma)}{1+2\beta} \tag{B.4}$$

$$c_1^* = 3w - \gamma - \frac{2\beta(3w-\gamma)}{1+2\beta}$$

$$c_1^* = \frac{3w-\gamma}{1+2\beta} \tag{B.5}$$

From (B.2) and (B.4):

$$c_2^* = \frac{2\beta(3w-\gamma)}{(1+2\beta)(1+\beta)} \tag{B.6}$$

From (B.1), (B.3) and (B.4):

$$c_3^* = \frac{2\beta^2(3w-\gamma)}{(1+2\beta)(1+\beta)} \tag{B.7}$$

D.II. Case 2: Equilibrium When Worker is Paid at a High Frequency: (Same) Salary is Paid Every Period

When the worker receives the salary in each period t the consumption path is: $c_1 = c_2 = c_3 = w - \gamma$. This is because $0 \leq \beta \leq 1$, the individual will try to consume more during the first period. However, because he gets the same wage every month and he cannot transfer consumption from the future to the present, his consumption at period 1 will equal the wage received in that period. The same happens in the remaining periods.

D.III. Welfare

Utility at t=0 under a Low Frequency of Wage Payment

$$\tilde{u}_0 = ln(c_1) + ln(c_2) + ln(c_3)$$

$$\tilde{u}_0 = ln\left(\frac{3w-\gamma}{1+2\beta}\right) + ln\left(\frac{(3w-\gamma)2\beta}{(1+2\beta)(1+\beta)}\right) + ln\left(\frac{(3w-\gamma)2\beta^2}{(1+2\beta)(1+\beta)}\right) \quad \text{(B.8)}$$

Utility at t=0 under a High Frequency of Wage Payment

$$\hat{u}_0 = ln(c_1) + ln(c_2) + ln(c_3)$$

$$\hat{u}_0 = 3ln\,(w-\gamma) \quad \text{(B.9)}$$

D.IV. Congestion

D.IV.1. Welfare

Worker's Long-run Utility When She Receives One Upfront Payment:

$$\begin{aligned}\tilde{u}_{i0} &= ln(c_{i1}) - z_1 + ln(c_{i2}) - z_2 + ln(c_{i3}) - z_3 \\ \tilde{u}_{i0} &= ln(c_{i1}) - a\left(\int c_{i1}\,di\right)^2 + ln(c_{i2}) - a\left(\int c_{i2}\,di\right)^2 + ln(c_{i3}) - a\left(\int c_{i3}\,di\right)^2\end{aligned}$$

Total welfare for all consumers is: $\hat{U}_0 = \int \tilde{u}_{i0}\,di$

$$\hat{U}_0 = \int \left[ln(c_{i1}) - a\left(\int c_{i1}\, di\right)^2 + ln(c_{i2}) - a\left(\int c_{i2}\, di\right)^2 + ln(c_{i3}) - a\left(\int c_{i3}\, di\right)^2 \right] di \qquad \text{(B.10)}$$

Because there is a mass one of identical consumers, the total long-run utility for all consumers is:

$$\tilde{U}_0 = ln(c_{i1}) - a\left(c_{i1}\right)^2 + ln(c_{i2}) - a\left(c_{i2}\right)^2 + ln(c_{i3}) - a\left(c_{i3}\right)^2$$

$$\tilde{U}_0 = ln\left(\frac{3w-\gamma}{1+2\beta}\right) - a\left(\frac{3w-\gamma}{1+2\beta}\right)^2 + ln\left(\frac{(3w-\gamma)2\beta}{(1+2\beta)(1+\beta)}\right) - a\left(\frac{(3w-\gamma)2\beta}{(1+2\beta)(1+\beta)}\right)^2 + ln\left(\frac{(3w-\gamma)2\beta^2}{(1+2\beta)(1+\beta)}\right) - a\left(\frac{(3w-\gamma)2\beta^2}{(1+2\beta)(1+\beta)}\right)^2 \qquad \text{(B.11)}$$

Worker's Long-run Utility When Wages Are Paid Every Period:

The long-run utility of the representative consumer is:

$$\hat{u}_{i0} = ln(w-\gamma) - z_1 + ln(w-\gamma) - z_2 + ln(w-\gamma) - z_3$$

Then, following the same procedure as before, the long-run utility of all consumers (mass one) is:

$$\hat{U}_0 = 3ln\left(w-\gamma\right) - 3a\left(w-\gamma\right)^2 \qquad \text{(B.12)}$$