Date

Microeconomics Paper 130522

1a $u = \ln x + 2\ln y$

$MU_x = \partial u/\partial x = 1/x$

$MU_y = \partial u/\partial y = 2/y$

$MRS = -MU_x/MU_y = -y/2x$

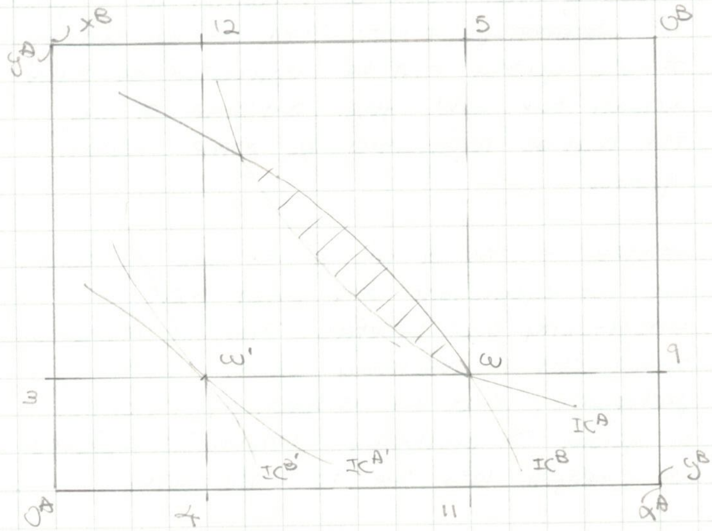
$\cancel{MRS(11,3) = -3/22}$

$\cancel{MRS(5,9) = -9/10}$

$MRS^A = -y^A/2x^A = -3/22$

$MRS^B = -y^B/2x^B = -9/10$

$MRS^A \neq MRS^B \Rightarrow$ there exists some mutually profitable exchange between A and B $\Rightarrow$ the given allocation is not Pareto efficient.



At the given allocation w, A and B's indifference curves are IC^A, IC^B respectively. Any ~~allocation~~ allocation ~~strictly~~ above each indifference curve is ~~strictly~~ preferred by that consumer. Then any ~~p~~ allocation represented by some point in the shaded area (excluding the intersections of IC^A and IC^B) is ~~wea~~ strictly preferred to w by at least one consumer and weakly preferred by by both. All such points Pareto dominate w, ~~since~~ so w is not Pareto optimal. The slope of IC^A and IC^B at w are given by MRS^A and MRS^B respectively.

b Given that $y^A = 3$, $y^B = 9$, $MRS^A = MRS^B \Leftrightarrow -3/2x^A = -9/2x^B \Leftrightarrow x^B = 3x^A \Leftrightarrow x^A = 4, x^B = 12$.

This allocation is represented by w' in the diagram above. This point is Pareto efficient ~~since~~ because there is no ~~point such~~ alternative allocation such that both consumers are ~~better off and~~ weakly better off and at least one is strictly better off. Graphically, this is reflected in the tangency of $IC^{A'}$ and $IC^{B'}$ at w'. There is no point that lies above both indifference curves.

When $MRS^A = MRS^B$, there is no mutually profitable trade.

c No. w' is obtained from w by a transfer of x from A to B. ~~By inspection~~, the common utility function is strictly monotonic in x, so such a transfer leaves A strictly worse off and B strictly better off.

di $u^A = \ln x^A + 2\ln y^A$

$u^B = \ln x^B + 2\ln y^B$

$x^B = 16 - x^A$, $y^B = 12 - y^A$

$u^B = \ln(16 - x^A) + 2\ln(12 - y^A)$

$U = u^A + u^B = \ln x^A + \ln(16 - x^A) + 2\ln y^A + 2\ln(12 - y^A)$

$= \ln[x^A(16 - x^A)\, y^{A^2} (12 - y^A)^2]$

~~By strict monotonicity of ln, the maximum of U coincide with the maximum of~~

$\cancel{V = x^A(16 - x^A)\, y^{A^2}(12 - y^A)^2}$

$\cancel{FOC\,x^A: (16 - x^A) - x^A = 0 \Rightarrow x^A = 8}$

$\cancel{FOC\,x^A: (16 - x^A)}$

$FOC\,x^A: 1/x^A + -1/(16 - x^A) = 0 \Rightarrow 16 - 2x^A = 0 \Rightarrow x^A = 8$

$FOC\,y^A: 2/y^A + -2/(12 - y^A) = 0 \Rightarrow 12 - 2y^A = 0 \Rightarrow y^A = 6$

$SOC\,x^A: -x^{A^{-2}} + (16 - x^A)^{-2}(-1) < 0$

$SOC\,y^A: -2y^{A^{-2}} + (12 - y^A)^{-2}(-1) < 0$

Total utility U is a maximum at $x^A, y^A = 8, 6 \Rightarrow x^B, y^B = 8, 6$.

Given that consumers have identical, concave ~~utility functions~~ (hence decreasing marginal utility in each good) and strictly monotonic (hence positive marginal utility) utility functions, total utility is maximised by an equal distribution of both goods.

ii ~~Minimum utility~~ Given that consumers have strictly monotonic utility functions, the minimum utility ~~is~~ is maximised when consumers have equal utility. At any allocation where consumers have non equal utility, minimum utility can be increased by some sufficiently small transfer of either good from the consumer with higher utility to the consumer with lower utility. This condition is satisfied at the above allocation, which maximises total utility. So the above allocation also maximises minimum utility.

The utilitarian and Rawlsian social choice functions coincide in this case because consumers have identical utility functions. This result does not generally obtain.

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2a. The firm's profit maximisation problem is

$\max_h \ \pi(h) = 24h - \cancel{4h^2}\ 2h^2$

$FOC_h: 24 - \cancel{8}4h = 0 \Rightarrow h = \cancel{3}\ 6$

$SOC_h: \cancel{-8}-4 < 0$

Profit is a maximum at $h = \cancel{3}6$. This is the ~~leve~~ level of pollution chosen by the firm.

b At the ~~prof~~ Pareto optimal level of pollution, the sum of profit and ~~con~~ consumer utility (given that it is linear in the consumer's wealth) is a maximum. Every other candidate optimum is Pareto dominated by ~~so~~ this level of pollution with some wealth transfer such that both the firm and the consumer are strictly better off.

$\max_h \ \pi(h) + \phi(h;\theta) = w_f + 24h - \cancel{4h^2}2h^2 + w_c - 6\theta h - h^2$

$FOC_h: 24 - \cancel{8}4h - 6\theta - 2h = 0 \Rightarrow \cancel{4h} \ 6h = 24 - 6\theta \Rightarrow h = 4 - \theta$

$SOC_h: -6 < 0$

The sum of profit and utility is ~~maximise~~ a maximum at $h = 4 - \theta$. Then, the Pareto optimal level of pollution is $h = 4 - \theta$.

The Pareto optimal level of pollution is decreasing in θ because the consumer's marginal disutility from pollution, $6\theta + 2h$ is increasing in θ while the firm's marginal profit from pollution $24 - 4h$ is independent of θ. Then, an increase in θ increases the marginal ~~cost of~~ social cost of pollution but has no effect on the marginal social benefit. So the intersection of marginal social cost and marginal social benefit is at a lower level of pollution. Total social surplus is maximised at a lower level of pollution, and by the above argument, this level of pollution is Pareto optimal.

c The optimal Pigouvian tax is equal to the marginal external cost at the socially optimal level of pollution. The marginal external cost is equal to the consumer's marginal disutility from pollution (given that the consumer's utility is linear in consumer's wealth.

$|t| = \partial\phi/\partial h \,|_{h=4-\theta} = -6\theta - 2h = -6\theta - 2(4-\theta) = -8 - 4\theta$

$t = 8 + 4\theta$

The optimal Pigouvian tax is increasing in θ because the marginal external cost at the social optimum, which the ~~Pigouvian tax~~ optimal Pigouvian tax requires the firm to internalise, is increasing in θ, which in turn is because the marginal ~~social cost~~ external cost of pollution is increasing in θ.

Under the optimal Pigouvian tax, the firm's marginal private benefit at the social optimum is zero. This level of pollution is privately optimal for the firm.

d Expected deadweight loss due to uncertainty is independent of whether a tax or quota is imposed because the marginal social benefit of pollution, which is the firm's marginal profit from pollution, is certain. Then, choosing some level of tax t^* determines the equilibrium level of pollution with certainty, and so is equivalent to choosing that level of pollution as a quota h^*. ~~Similarly, ch~~ Then, ~~a~~ the outcome of any quota can be replicated by some known tax and the outcome of any tax can be replicated by some known quota.

~~Whether a tax or q~~ A tax and a quota are not equivalent only when there is uncertainty over benefits. Then, if marginal social cost is relatively elastic a tax is preferable, and if it is relatively inelastic, a quota is preferable (minimises expected deadweight loss due to uncertainty).

When ~~at~~ ~~social~~ marginal social cost is relatively elastic, there is large variance in the socially optimal quantity, so it is preferable to allow quantities to adjust, and set a tax.

3a A Nash equilibrium is some strategy profile such that no player has strict incentive to deviate given the strategy of all other players. In symbols, a NE is ~~some σ~~ any strategy profile $\sigma^* = (\sigma_1^*, \ldots, \sigma_n^*)$ such that for all players $i \in N = \{1, \ldots, n\}$, for all strategies σ_i', $\pi_i(\sigma_i^*, \sigma_{-i}^*) \geq \pi_i(\sigma_i', \sigma_{-i}^*)$.

In a sequential game, the refinement used is subgame perfect equilibrium. A SPE is a NE that ~~ind~~ induces a NE in every subgame. SPE eliminates NE that involve non-credible threats that are time inconsistent.

For example, in the simple market entry game, one NE is such that the incumbent plays the strategy of always preying on an entrant and the entrant plays the strategy of never entering. This NE is not a SPE because the incumbent's threat of preying on an entrant is not credible ~~time consistent~~. In the off equilibrium path subgame where the entrant has entered, the incumbent has strict incentive to accommodate the entrant, so ~~it plays~~ the above strategy profile does not induce ~~a~~ a NE in this subgame.

b

	O	N
O	$\underline{2}$, $\underline{2}$	1, 1
N	1, 1	$\underline{4}$, $\underline{4}$

Best responses underlined.

By inspection, there are two pure NE where players play pure mutual best responses. These are (O, O) and (N, N). The game is a coordination game.

(N, N) is Pareto efficient because each player's payoff is strictly maximised, ~~no strategy profile other strategy profi~~ each player is strictly worse off at any other strategy profile.

c Solve for SPE by backward induction.

If the first mover P1 (Row, without loss of generality, given that ~~the game is symmetric~~ payoffs are symmetric) plays O, then in the second stage, P2 best responds with O, this yields $\pi_1 = 2$. If ~~the second per~~ P1 plays N, then in the second stage, P2 best responds with ~~O~~ N, this yields $\pi_1 = 4$. So P1 optimally chooses N. The SPE is the strategy profile under which P1 plays N, and P2 plays O if P1 played O, and N if P1 played N.

P2's strategy is a complete contingent (on past play by P1) plan of action, so it specifies off equilibrium path actions.

d The revised payoff matrix is the following

	O	N
O	$\underline{2}$, $\underline{2}$	1, $\underline{2}$
N	$\underline{2}$, 1	$\underline{5}$, $\underline{5}$

N is weakly dominant for each player. There remain two pure NE (O, O) and (N, N) because even with the lower cost, unilateral deviation from ~~O is~~ (O, O) is not strictly profitable.

Neither iterated strict dominance nor NE yield a unique prediction of the outcome, so neither common knowledge of rationality nor common knowledge of rationality and correct beliefs yields a unique ~~outco pred~~ outcome.

(N, N) is risk dominant and involves playing weakly dominant strategies, so it is a reasonable prediction.

~~The answer to SPE of the sequential game~~ There is now a multiplicity of SPE in the sequential game, but the ~~SPE~~ outcome of each SPE, that both players play N with certainty is unchanged. Any strategy profile such that P1 plays N, and P2 plays any mix if P1 plays O and plays N if P1 plays N is a SPE. This is because in the O-subgame, P2 is indifferent between N and O so any potentially degenerate mix is a best response. In the N subgame, N remains a strict unique best response. P1 strictly prefers the outcome of the N subgame, so P1 continues to play N.

4a The certainty equivalent $CE(L)$ of lottery L to agent A is the ~~amount~~ certain amount such that $[1; CE(L)] \sim_A L$.

Agent A should participate in lottery L, ~~other~~ which is a lottery in final wealth values iff $CE(L)$ ~~≠~~ is ~~strictly~~ greater than A's final wealth if A does not participate. If the two are equal, A is indifferent.

b $L^S = [\frac{1}{2}, \frac{1}{2}; 5, 20]$

$L^J = [\frac{1}{2}, \frac{1}{2}; 4, 25]$

$U(L^S) = \frac{1}{2}u(5) + \frac{1}{2}u(20) = \frac{1}{2}\ln 5 + \frac{1}{2}\ln 20 = \frac{1}{2}\ln 100 = \ln 10$

$U(L^J) = \frac{1}{2}u(4) + \frac{1}{2}u(25) = \frac{1}{2}\ln 4 + \frac{1}{2}\ln 25 = \frac{1}{2}\ln 100 = \ln 10$

$[1; CE(L^S)] \sim L^S \iff \ln CE(L^S) = \ln 10 \iff CE(L^S) = 10$

$[1; CE(L^J)] \sim L^J \iff \ln CE(L^J) = \ln 10 \iff CE(L^J) = 10$

Given that $w^S = w^J$. Let $w = w^S = w^J$.
Suppose $w > 10$, then $w^S > CE(L^S)$, $w^J > CE(L^J)$, so both accept. Suppose $w < 10$, then $w^S < CE(L^S)$ and $w^J < CE(L^J)$ so neither accept. Suppose $w = 10$, then both are indifferent. Consequently, either both accept or neither accept (or both are indifferent).

L^S and L^J denote the respective gambles, U denotes the common utility function over lotteries. u denotes the common Bernoulli utility function. It is supposed that both S and J maximise expected utility. The inferences follow ~~from~~ by definition of CE and the decision rule given in (a).

c The pooled lottery in final wealth values faced by either agent is

$L^P = [\frac{1}{4}, \frac{1}{4}, \frac{1}{4}, \frac{1}{4}; \frac{5+4}{2}, \frac{5+25}{2}, \frac{20+4}{2}, \frac{20+25}{2}]$
$= [\frac{1}{4}, \frac{1}{4}, \frac{1}{4}, \frac{1}{4}; \frac{9}{2}, 15, 12, \frac{45}{2}]$

$U(L^P) = \frac{1}{4}\ln(\frac{9}{2}) + \frac{1}{4}\ln(15) + \frac{1}{4}\ln(12) + \frac{1}{4}\ln(\frac{45}{2})$
$= \frac{1}{4}\ln(2^{-1}3^2 3^1 5^1 2^2 3^1 2^{-1} 3^2 5^1)$
$= \frac{1}{4}\ln(3^6 5^2)$
$= \ln 3^{3/2} 5^{1/2}$

$[1; CE(L^P)] \sim L^P \iff \ln CE(L^P) = \ln 3^{3/2} 5^{1/2}$
$\iff CE(L^P) = 3^{3/2} 5^{1/2} = 11.619$

$CE(L^P) < 12$, neither agent finds even the pooled lottery preferable to non-participation, ~~neither agent should participate in the pooled~~ it would not be advisable ~~to pool the lotteries or~~ participate in this pooled lottery.

d The pooled lottery in final wealth values faced by either agent is

$L^P = [\frac{1}{2}, \frac{1}{2}; \frac{20+4}{2}, \frac{25+5}{2}] = [\frac{1}{2}, \frac{1}{2}; 12, 15]$

~~$U(L^P) = \frac{1}{2}\ln 12 + \frac{1}{2}\ln 15 = \frac{1}{2}\ln 2^2 3^1 3^1 5^1 = \ln 6\sqrt{5}$~~

~~$CE(L^P) = 6\sqrt{5} = 13.416 > w = 12$~~

Consider some Bernoulli utility function v, which is potentially much more concave than u, representing the preferences of a much more risk averse agent. Let V denote the corresponding utility function over lotteries. Suppose that v is strictly monotone, and represents well-behaved preferences over final wealth values.

The lottery ~~faced by~~ in final wealth values faced by each agent if they do not participate is

$L^0 = [1; 12]$

$V(L^P) = \frac{1}{2}v(12) + \frac{1}{2}v(15) > \frac{1}{2}v(12) + \frac{1}{2}v(12)$
$= v(12) = V(L^0)$

Every expected utility maximiser with strictly monotonic Bernoulli utility strictly prefers L^P to L^0. S and J should participate regardless of their degree of risk aversion. L^P FOSDs L^0.

5a if the quality of each bicycle is commonly known, then ~~there is a market~~ at equilibrium, each bicycle is owned by the consumer with the higher valuation for that bicycle. At any candidate equilibrium where this is not so, there is a mutually profitable trade at some intermediate price.

Where the qualities are commonly known, there is a separate market for bicycles of each quality.

At equilibrium, ~~the~~ H (the high quality bicycle) is owned by a Y, M is owned by a X, L is owned by a Y.

b For price $p<20$, no B are offered for sale, but each Y demands one B of any type, there is no equilibrium at any such p.

~~At for p 20<p<30~~,

At $p=20$, at most L is offered for sale, each Y demands one L, three units of L are demanded, there is no equilibrium at $p=20$

For $20<p<30$, L is offered for sale, and three units of L are demanded, there is no equilibrium.

At $p=30$, L is offered for sale, up to three units of L are demanded, there is an equilibrium at $p=30$ such that ~~one~~ exactly one unit of L is demanded. L is sold from the X owner to one Y.

For $30<p<50$, L is offered, no units of L are demanded, there is no such equilibrium.

At $p=50$, if only L is offered for sale, demand is zero, if L and M are offered for sale, each type Y has expected valuation 30 and demand is zero, if L, M, and H are offered for sale, each type Y has expected valuation 40 and demand is zero, so there is no equilibrium at any such p.

For $p>50$, all B are offered, each Y has expected valuation 40, demand is zero, there is no equilibrium.

c For $p<30$, there is zero supply, so no equilibrium. For $p=30$, if only L is supplied, ~~there~~ each X has expected valuation 20, so there is no demand, and no equilibrium.

If L and M are supplied, each X has expected valuation 35, so three units are demanded and there is no equilibrium. Similarly for $30<p<35$. At $p=35$, L and M are supplied, each X has expected valuation 35, so up to three units are demanded. There is an equilibrium at this price where L and M are supplied and exactly two X buy. For $35<p<60$, only L and M are supplied, demand is zero, so there is no equilibrium. At $p=60$, L and M and possibly H are supplied. ~~Expected valua~~ Each X has expected valuation no greater than 50, so demand is zero and there is no equilibrium. Likewise for $p>60$

At equilibrium, $p=35$, L and M are each sold from one Y to one X.

H is owned by a Y, M and L are each owned by a X.

d ~~The equilibrium outcome is unchanged, no further trade occurs~~

For $p<20$, supply is zero, demand is two, there is no equilibrium. For $p=20$, supply is at most one (L), demand is two, there is no equilibrium, likewise for $20<p<30$. For $p=30$, there is an equilibrium where L is supplied and demand is one. For $30<p<50$, L is supplied, demand is zero, so there is no equilibrium. For $50\leq p<60$, L and possibly M are supplied, demand is zero, so there is no equilibrium. For $p\geq 60$, L, M and possibly H are supplied, each consumer has expected valuation weakly less than 60, demand is zero, there is no equilibrium.

The unique equilibrium is at $p=30$, where L is supplied and one unit of L is demanded. The equilibrium outcome coincides with that where types are commonly known.

Whether adverse selection results from asymmetric information depends on the initial allocation of goods and the possibility of further rounds of trade.

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11a Firm 2's profit maximisation problem is

~~$\max_{q_2} p(q_1+q_2)q_2 - (F+4q_2)$~~

$\max_{q_2} \pi_2(q_2)$

where $\pi_2(q_2) = p(q_1+q_2)q_2 - (F+4q_2)$

$= (40-q_1-q_2)q_2 - 4q_2$

FOC: $\partial\pi_2/\partial q_2 = (40-q_1-q_2) - q_2 - 4 = 0$

$\Rightarrow 36-q_1 = 2q_2 \Rightarrow q_2 = 36-q_1/2$

SOC: $\partial^2\pi_2/\partial q_2^2 = -2 < 0$

$q_2 = 36-q_1/2$ solves firm 2's profit maximisation problem, given $F=0$ and q_1. Firm 2's best response function is $q_2(q_1)\ 36-q_1/2$.

Firm 1's profit function is

$\pi_1(q_1,q_2) = p(q_1+q_2)q_1 - 2q_1$

$= (40-q_1-q_2)q_1 - 2q_1$

Solve for the subgame perfect equilibrium by backward induction.

By substitution,

$\pi_1(q_1) = (40 - q_1 - 36-q_1/2)q_1 - 2q_1$

$= (22 - q_1/2)q_1 - 2q_1$

$\max_{q_1} \pi_1(q_1)$

FOC: $(22 - q_1/2) - q_1/2 - 2 = 0$

$\Rightarrow q_1 = 20$

SOC: $-1 < 0$

$q_1 = 20$ solves firm 1's profit maximisation problem, given that firm 2 plays the above best response.

~~$\pi_1(q_1,q_2) = p(q_1+q_2)q_1 - 2q_1$~~

~~$= (40-q_1-q_2)q_1 - 2q_1$~~

$q_1 = 20 \Rightarrow q_2 = 36-20/2 = 8$

$\Rightarrow p = 40-q_1-q_2 = 12$

$\pi_1 = pq_1 - 2q_1 = 200$

$\pi_2 = pq_2 - 4q_2 = 64$

Firm 1 has a larger profit because firm 1 has lower marginal cost, and because there is a first mover advantage in the Stackelberg game. There is such a first mover advantage because quantities are strategic substitutes. By choosing a higher quantity, firm 1 reduces the marginal profit from quantity for firm 2, this induces firm 2 to choose lower quantity which benefits firm 1.

b In the third stage, given firm 1's quantity q_1, and that firm 2 entered, firm 2 maximises profit as above. The best response of firm 2 is unchanged because ~~the increase in F~~ ~~profit~~ maximisation of net (of fixed cost) profit coincides with maximisation of gross profit, i.e. profit when $F=0$.

~~$q_2 = 36-q_1/2$~~

~~$\pi_2(q_1) = p(q_1 + 36-q_1/2)(36-q_1/2)$~~

At SPE, $q_2 = 36-q_1/2$, then

$\pi_2(q_1) = p(q_1, 36-q_1/2)\, 36-q_1/2 - (F + 4(36-q_1/2))$

$= (40-q_1 - 36-q_1/2)(36-q_1/2) - (4 + 2(36-q_1/2))$

$= (22-q_1/2)(18-q_1/2) - 4 - (72-2q_1)$

$= (396 + q_1^2/4 - 20q_1) - 4 - (72-2q_1)$

$= q_1^2/4 - 18q_1 + 320$

$\pi_2(q_1) = 0 \iff q_1 = 18 \pm \sqrt{324-320}\,/\,2/4 = 36 \pm 4 = 40$ or 32.

Reject $q_1 = 40$ because $q_1 = 40 \Rightarrow q_2 = -2$

Supposing that firm 2 enters iff $\pi_2 > 0$, firm 1 can deter entry by choosing $q_1 = 32$. Then firm 2 does not enter and $q_2 = 0$. $p = 40-q_1-q_2 = 8$

$\pi_1 = pq_1 - 2q_1 = 192$.

If firm 1 accommodates entry, it does so by choosing $q_1 = 20$ as found in (a) and has profit $\pi_1 = 200$. The optimal output when accommodating entry is unchanged because firm 1's profit function and firm 2's best response function (given that it enters) is unchanged.

Then, it is optimal for firm 1 to accommodate entry rather than deter entry. At SPE firm 1 chooses $q_1 = 20$, firm 2 chooses to enter and $q_2 = 8$ (as found in (a), because firm 2's best response function is unchanged).

c When $F = 36$, firm 2's best response function given that it enters is unchanged, so firm 2's (maximum) (net) profit as a function of q_1 is unchanged, except in the constant term.

$\pi_2(q_1) = q_1^2/4 - 18q_1 + 324 - F$

$= q_1^2/4 - 18q_1 + 288$

Continuing to suppose firm 2 enters iff $\pi_2 > 0$, firm 1 deters entry (supposing that this constraint binds) by choosing q_1 such that

$\pi_2(q_1) = 0 \iff q_1 = 18 \pm \sqrt{324-288}\,/\,2/4 = 36 \pm 12 = 24$ or 48

Again reject $q_1 = 48$ because $q_1 = 48 \Rightarrow q_2 < 0$.

Firm 2 does not enter if $q_1 \geq 24$

Firm 1's monopoly profit function is

$\pi_1(q_1, q_2=0) = p(q_1)q_1 - 2q_1 = (38-q_1)q_1$

This is a maximum at $q_1 = 19$ and is decreasing in q_1 for $q_1 \geq 19$, so the earlier supposition that if firm 1 deters entry the entry deterrence constraint binds is validated.

if firm 1 deters entry it ~~chooses~~ optimally does so by choosing $q_1 = 24$ and enjoys monopoly profit $\pi_1(24, q_2=0) = 336$. This is greater than the maximum profit from accommodation, which remains at 200 because firm 2's best response is unchanged hence firm 1's maximum profit given that firm 2 enters is unchanged.

It is optimal for firm 1 to deter entry, firm 1 chooses $q_1 = 24$, firm 2 does not enter. Off the equilibrium path, if $q_1 < 24$, firm 2 enters and chooses $q_2 = 36 - q_1/2$, if $q_1 < 24$, firm 2 does not enter still.

d $F = 100$, $\pi_2(q_1) = q_1^2/4 - 18q_1 + 224$

$\pi_2(q_1) = 0 \iff q_1 = (18 \pm \sqrt{324 - 224})/2/4 = 8$ or 28

$\pi_2(q_1) \leq 0 \iff 8 \leq q_1 \leq 28$

~~within this interval, firm 1's profit function is the monopoly profit function~~

Firm 2 does not enter for all such q_1. Within this interval, firm 1's profit function is the monopoly profit function

$\pi_1(q_1, q_2=0) = (40-q_1)q_1 - 2q_1 = (38-q_1)q_1$

FOC: $38 - q_1 - q_1 = 0 \Rightarrow q_1 = 19$

SOC: $-2 < 0$

~~the maximum~~ is ~~??~~

$q_1 = 19$ maximises monopoly profit and lies within the interval, so if firm 1 deters entry, it chooses $q_1 = 19$. Then, firm 1 has profit $\pi_1 = (38-19)19 = 361$.

~~By inspection of~~

$\pi_1(q_1, q_2) = (40 - q_1 - q_2)q_1 - 2q_1$

Firm 1's profit is strictly decreasing in q_2 (for $q_1 \neq 0$), hence ~~??~~ the maximum ~~achievable~~ accommodation profit is less than the maximum monopoly profit above. Firm 1 ~~optimally~~ chooses to deter entry by choosing $q_1 = \cancel{36}$ 19.

At SPE, firm 1 chooses $q_1 = 19$. Firm 2 enters iff $q_1 < 8$ or $q_1 > 28$, and chooses $q_2 = 36 - q_1/2$ if it enters (0 otherwise). ~~??~~

Technically, in this case, entry is blockaded, not merely deterred.

e In (b), entry is accommodated. In (c), entry is deterred. In (d) entry is blockaded. Entry is accommodated in (b) because the fixed cost F is sufficiently low such that in order to make entry unprofitable for firm 2, firm 1 must choose a very large quantity that yields ~~??~~ less profit than sharing the market. In (c), the fixed cost of entry is larger, so firm 1 need not act so aggressively to deter entry and can deter entry by choosing some moderate output which yields greater profit than sharing the market, so this is optimal. In (d), the fixed cost of entry is so large that even when firm 1 produces the monopoly output, no ~~??~~ non-zero output is profitable for firm 2, so firm 1 produces the monopoly output and is ~~not in practice threatened by entry~~: effectively unthreatened by entry.